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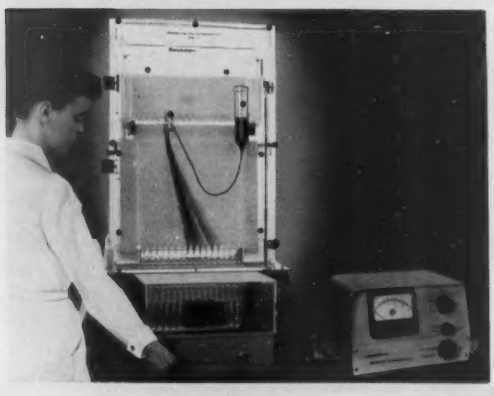

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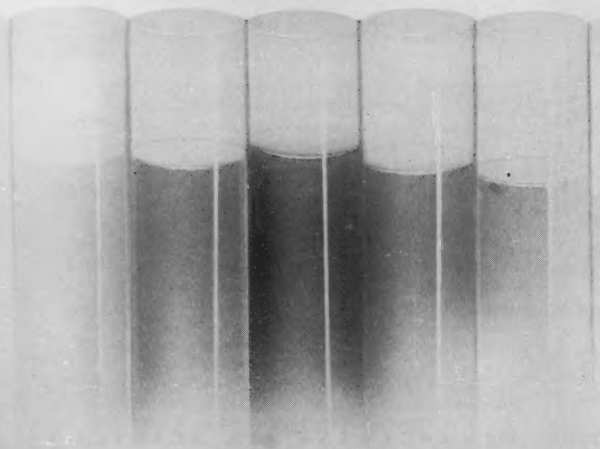

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Sir James Jeans . . . on the quest for knowledge

"Yet we may reflect that physics and philosophy are at most a few thousand years old, but probably have lives of thousands of millions of years stretching away in front of them. They are only just beginning to get under way, and we are still, in Newton's words, like children playing with pebbles on the sea-shore, while the great ocean of truth rolls, unexplored, beyond our reach. It can hardly be a matter for surprise that our race has not succeeded in solving any large part of its most difficult problems in the first millionth part of its existence. Perhaps life would be a duller affair if it had, for to many it is not knowledge but the quest for knowledge that gives the greater interest to thought — to travel hopefully is better than to arrive."

—Physics and Philosophy, 1942

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Letters

Adoption of the Metric System

Pursuant to the resolution adopted unanimously at the business session of the American Geophysical Union on 7 May 1958 [*Trans. Am. Geophys. Union* **39**, 558 (1958)], Maurice Ewing, president, appointed a Committee on Adoption of the Metric System in the United States.

Bills for the compulsory adoption of the metric system in the United States have been more than once presented to Congress, but they have not been enacted into law, the principal reason being that in each case the effective date proposed followed too soon after passage of the bill. An early effective date would undoubtedly work a severe hardship on the adult population not familiar with the metric system, and it would make obsolete a prohibitive number of everyday items pertaining to weights and measures.

A solution would appear to be a bill to make the metric system the only official system of weights and measures in the United States, effective in not less than one generation (33 years) after passage of the bill. Following this action by Congress, the grade schools and high schools would begin immediately to teach children the metric along with the English system and, during the transition period, would place more and more emphasis on the metric system. At the end of the transition period the English system would still be taught, but the emphasis would be just the reverse of what it is today. A long transition period would result in a smooth change. In a generation most items of equipment involving weights and measures normally become obsolete or are worn out and replaced. Also, persons engaged in professions and trades now using the English system exclusively would normally retire during this period and would be replaced by a new generation thoroughly educated and trained in the metric system.

The questionnaire given below has been prepared for readers for the purpose of gathering statistical information to indicate the degree of interest in this matter. The metric committee of the American Geophysical Union will welcome any comments. Those submitting replies are urged to suggest solutions to difficulties which may be foreseen in the adoption of the metric system.

Additional copies of the questionnaire are available upon request. A small effort on the part of readers to complete and mail this questionnaire will be of invaluable help to the committee. The completed questionnnaire should be mailed to the Executive Secretary, American Geophysical Union, 1515 Massachusetts Ave., NW, Washington 5, D.C.

FLOYD W. HOUGH

Arlington, Virginia

Metric System Questionnaire.

1. Indicate professional field of interest in the AGU _____
2. What approximate percentages of units used in your work are:
   Metric ____ British ____ Other ____
3. Would it be to your advantage if a complete conversion to the metric system could eventually be made? Yes ____ No ____
4. How long a period of time (in years) should be allowed for the conversion?
   10 ____ 20 ____ 30 ____ 40 ____ 50 ____ Longer ____
5. Should the centigrade system of temperature measurement be adopted?
   Yes ____ No ____
6. Do you believe that United States export trade is suffering as a result of the use of British units? Yes ____ No ____ No opinion ____
7. Do you believe that the eventual adoption of the metric system is inevitable?
   Yes ____ No ____
8. Do you believe that the cost of a long-time conversion to the metric system would be prohibitive? Yes ____ No ____
9. In the event a joint committee were established to study the problem, circulate questionnaires, accumulate statistics, and report, it should be sponsored by (check one):
   Professional societies ____ Educational institutions ____ Industry ____
   Government ____
   How should the study be financed? _____
   Would you be willing to assist such a study group? Yes ____ No ____
   In what way? Financially ____ As an adviser ____
10. Additional remarks are welcome. _____

_____

_____

_____

_____

Signature (optional)

Vertebrate Metamorphosis

As a conclusion to his most interesting article, "The significance of vertebrate metamorphosis" [*Science* **128**, 1481 (1958)], Wald states: "Metamorphosis is a basic and general phenomenon, common to the whole vertebrate stock. It includes anatomical, physiological, and—perhaps prior to these—biochemical components, all designed to prepare the animal to leave its natal environment. Necessarily, in order to reproduce, the animal must eventually return, so completing its life cycle. . . ."

As far as the lower vertebrates are concerned, the examples which are listed by the author (species such as the sea lamprey, fresh-water eel, salmon, and certain amphibians) support such a conclusion very well. However, these examples alone do not make it valid for the whole vertebrate stock, mainly because these are illustrations of the *exceptional* rather than the *usual* kind of behavior among the vertebrates.

In the largest group of vertebrates, the fishes, the anadromous or catadromous life cycle that Wald speaks of is very rare indeed, being found in probably less than 1 percent of the known species. The vast majority of fishes remain in essentially the same environment into which they are born, having no need for, and showing no evidence of, metamorphic change to prepare the adult for entry into a special natal environment. In fishes there is often a profound change from a larval to adult stage, but this also is not one that necessarily prepares the animal for entry into a new environment in the sense referred to by Wald.

In regard to the higher vertebrates (mammals, birds, and reptiles), no one will deny that there are vast changes during embryological development, some of which are recapitulatory in nature, but the idea that there are changes at maturity which facilitate a return to the natal environment is indeed far-fetched. This is no more true of a spermatozoan than it is of the entire individual.

When one speaks of the natal (or more properly the prenatal) environment of a higher vertebrate embryo, the reference is almost always to the amnion and its contained fluid. Obviously, even a spermatozoan could not "return" to such an environment, since, in a given individual, such structures could not appear until long after the advent of fertilization.

The most momentous event in the course of evolution of the higher vertebrates is often considered to be the appearance of the amniote egg, primarily because *the adult was then freed of the necessity for a return to the natal environment* in order to reproduce.

Instead of the sweeping statement quoted at the beginning of this letter, I would like to take the opportunity to

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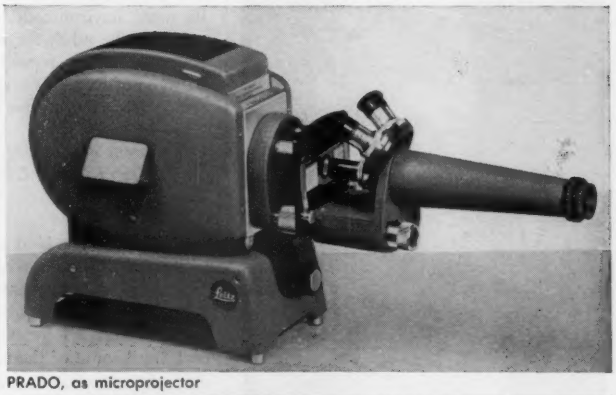

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offer a conclusion more in line with the evidence presented: Certain species of anadromous and catadromous fishes and probably many amphibians have a most interesting life cycle which includes two types of metamorphic change. The first is a preparation for the animal to leave its natal environment, and the second prepares the adult for re-entry into this environment for reproductive purposes. In some of its aspects, this second metamorphosis is the reverse of the first.

JOHN C. BRIGGS
Department of Anatomy, University of British Columbia, Vancouver

Briggs' letter is kind and generous, up to the peroration, in which it characterizes one of my statements as "sweeping." I hardly know what this means; but I suppose that all generalizations sound odd, until some of them, through reiteration, become familiar; and I have tried to keep my sweepings visible.

When I said that "metamorphosis is a basic and general phenomenon, common to the whole vertebrate stock," I meant in part that the relatively few observations of the kind discussed which have been made, already offer examples ranging from cyclostomes to mammals. In all justice, I meant to imply something more: that these phenomena already appear to be so widespread that whatever lines are eventually drawn to delimit them will have to be rather arbitrary.

Briggs stresses the point that anadromous and catadromous fishes include "probably less than 1 percent of the known species." This percentage is irrelevant; also, the phenomenon is not so limited. Beyond such extreme examples as cited in my paper, one encounters in fishes all degrees of the anadromous and catadromous condition. A. Meek says in his valuable book [*The Migrations of Fish* (Arnold, London, 1916), p. 18]: "Fish which leave the sea to spawn in estuaries only differ in degree from those which spawn just beyond brackish water, and there are fish which may spawn on the coast or in brackish water. So that it may be said all degrees of anadromous migration from mid-ocean to the upper limits of streams may take place and corresponding catadromous migrations. . . ."

Apart, however, from this range of life histories, it is generally agreed that the vast majority of contemporary fishes have migrated, perhaps repeatedly, between fresh waters and the sea during their evolution. A. S. Romer [*Man and the Vertebrates* (Penguin Books, Harmondsworth, Middlesex, 1954), vol. 1, pp. 39–40], for example, thinks that though the fishes as a class arose in fresh water, virtually all teleosts now found in fresh water have probably re-entered that environment from the sea: "The primitive teleosts, as we have suggested, evolved in the sea, and the vast majority of the group still live in salt water. They have, however, returned in considerable numbers to the fresh waters *which were the homes of their ancestors* . . ." (italics mine). It is probably true, therefore, that the great majority of what are now stenohaline fishes have had euryhaline forms in their ancestry, and so might exhibit metamorphic changes associated not only with their own migrations, but recapitulating those of their ancestors.

As for traces of biochemical metamorphosis in stenohaline fishes, Clyde Manwell has recently reported finding distinct embryonic hemoglobins in the spiny dogfish *Squalus suckleyi*, the skate *Raja binoculata*, and the marine teleosts, the sculpin *Scorpaenichthys marmoratus*, and the live-bearing surf-perch *Embiotoca lateralis* [*Physiol. Zoöl.* **31**, 93 (1958); *Science* **128**, 419 (1958); *ibid.* **126**, 1175 (1957)].

Altogether, therefore, Briggs comes perilously close to a sweeping statement in saying that "The vast majority of fishes remain in essentially the same environment into which they are born, having no need for, and showing no evidence of, metamorphic change to prepare the adult for entry into a special natal environment."

Finally, Briggs takes issue with my suggestion that the land vertebrates have not left either metamorphosis or problems of migration wholly behind. I speak of "*residues* of metamorphosis" and "*vestiges* of a second metamorphosis," and say with regard to the latter: "I suppose that puberty is so to be regarded. To be sure, this does not prepare a land vertebrate to migrate, for the natal environment is now segregated, and puberty prepares the animal only to mate." I had said earlier that land vertebrates "have developed two special devices" for pursuing ashore their embryogeny in water: "the boxed-in or cleidoic egg, and viviparity." Are these thoughts different from Briggs' remarks about the development of the amniote egg? And though it may be true that the natal environment of a land vertebrate "almost always" refers to the amniotic fluid, I hope the context of my discussion made it clear that I had included (see Fig. 18 of my article) the environment also of the egg, before and after fertilization.

I think that if Briggs will pursue the phenomena themselves, apart from conventional ways of talking about them, he will find, as I have, that it is difficult indeed to know where to stop.

GEORGE WALD
Biological Laboratories of Harvard University, Cambridge, Mass.

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SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at Business Press, Lancaster, Pa. The joint journal is published in the SCIENCE format. Entered at the Lancaster, Pa., Post Office as second class matter under the Act of 3 March 1879. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts, book reviews, and illustrations, see *Science* 125, 16 (4 Jan. 1957).

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Plums for the Teacher

A program of Summer Fellowships for secondary-school science teachers who want to increase their understanding of science through independent study at colleges or universities is being started this year by the National Science Foundation. The new program supplements the now-familiar Summer Institutes, which are also sponsored by NSF but in which colleges or universities plan courses of study for groups of teachers. The American Association for the Advancement of Science is administering at cost the first year of the Summer Fellowship program. Administrative responsibilities include selecting a panel of scientists to judge the applications for fellowships and transmitting the recommendations of the panel to NSF. Final decisions will be made by NSF, and the awards will be announced on 25 March.

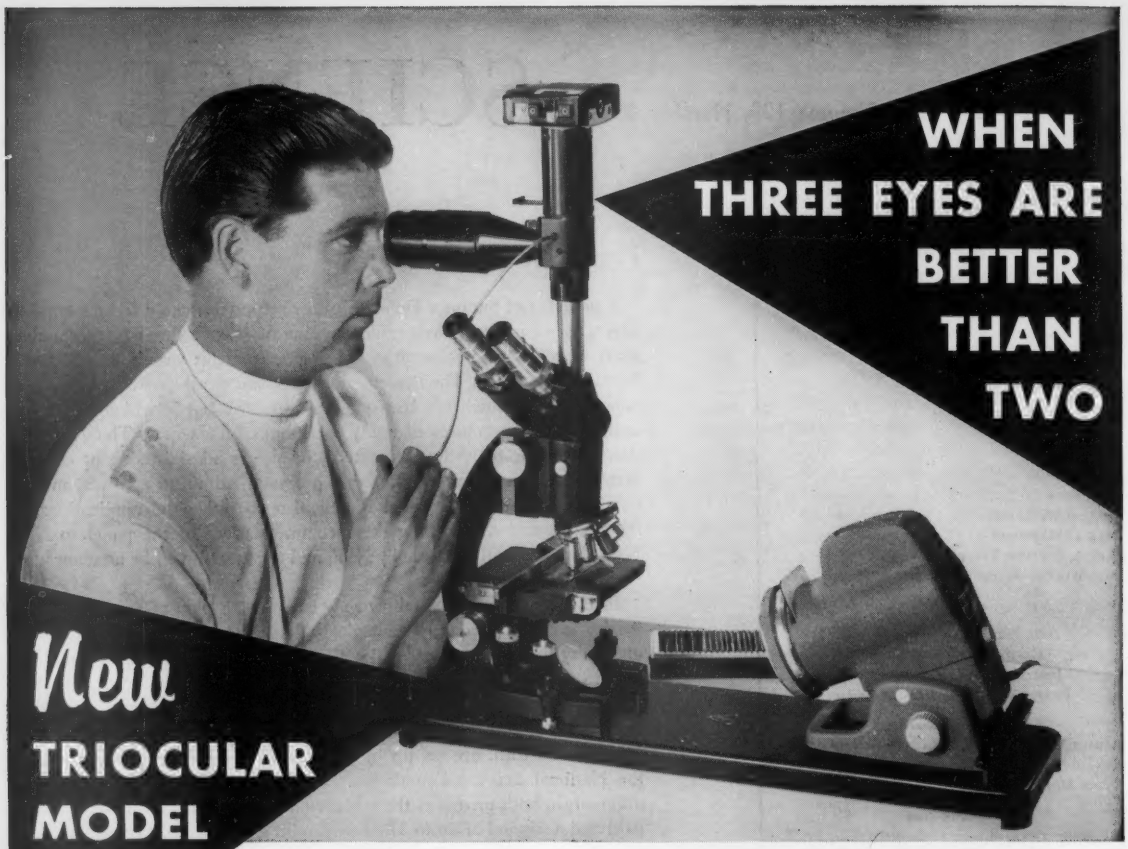
In the new program a fellow may carry out a plan of study in mathematics or in the physical or biological sciences at any accredited college or university in this country. Besides competing for fellowships on a national basis, a participant must gain admission to a college or university at which his plan can be carried out. In the Summer Institute program, there is no national competition. The teacher applies to one of the institutes, and the institutes, in turn, are set up by colleges and universities on grants from the National Science Foundation. Although the method of financing is different, in both programs the teacher-participant ends up with his tuition paid and a stipend of up to $75 a week plus allowances for dependents and travel.

The purpose of the Summer Fellowships, like that of the Summer Institutes, is to enable teachers of science to become better teachers by increasing their understanding of science. Although an applicant's plan of study may be part of his efforts to get an advanced degree in education, the plan must focus on a branch of mathematics or science, not on the history or philosophy of education or on methods of teaching. This emphasis also characterizes the other programs in education sponsored by NSF, which include programs for elementary-school teachers and college teachers and for institutes that are held during the academic year.

Initial plans for the Summer Fellowships call for 750 awards, which may cover up to three successive summers of study. The number of Summer Institutes open this year to secondary-school teachers will increase from the 121 open in 1958, averaging 50 teacher-participants each, to over 300, with awards being for one summer of study.

If the Summer Institute program proves effective, it could become the principal means by which the National Science Foundation supports summer study by teachers. With funds going directly to them, teachers can choose their courses from the fare offered by colleges and universities. There will be no need for special institutes, and the teachers will have more contact with the general body of students studying science. The future course of the new program will be determined in good part by whether applicants for Summer Fellowships succeed in producing plans as good as those offered by the Summer Institutes. It may be that the fellowships will prove suitable only for teachers of superior ability or for teachers whose background or interests call for unusual programs.

The National Science Foundation, and ultimately Congress, deserve our thanks for creating new opportunities for summer study, but then the teachers also deserve our thanks for seeking to increase their understanding of science.—J.T.



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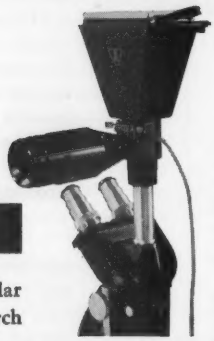

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CURRENT PROBLEMS IN RESEARCH

Biological Control of Insect Pests

Insect pests are economically controlled through the utilization of their natural enemies.

Charles A. Fleschner

Biological control is the practice of reducing the numbers of a pest by the use of "beneficial" organisms such as parasites, predators, and diseases. As an applied science, biological control is now some 70 years old, having had its first effective and sustained success in 1888 through the introduction of the vedalia beetle, *Rodolia cardinalis* (Muls.), from Australia for the control of cottony-cushion scale, *Icerya purchasi* Mask., on citrus in California. Since this initial success the biological method of pest control has spread rapidly throughout the world. It has been used effectively against a wide variety of noxious plants and animals. The greatest number of successes, however, have been in the control of insect pests of agricultural crops, and it is this aspect of biological control that is considered here (*1*). Throughout this article, except where otherwise stated, phytophagous mites are grouped with pest insects.

The biological method for insect pest control is based on the knowledge that there exists in nature a balance between plant-feeding insects and their enemies and that this balance may be shifted one way or another through the manipulation of environmental factors. This manipulation may involve one or more ecological approaches: (i) the importation of beneficial organisms, (ii) the mass production and periodic release of beneficial organisms, or (iii) the conservation and augmentation of native or established beneficial organisms.

The author is associate entomologist in the department of biological control, University of California Citrus Experiment Station, Riverside.

Importation of Beneficial Organisms

Plant-feeding insects of no economic importance in their native habitat are likely to become serious pests if moved to new areas free of their natural enemies. Most major insect pests of agricultural crops in the United States today originated in this manner. In many instances such pests have been controlled biologically through the introduction of their natural enemies from the native habitat.

The international movement of beneficial insects for pest control began in 1873 with the shipment of the mite *Rhizoglyphus phylloxerae* (Riley) from the United States to France for control of the grape phylloxera. This was followed in 1874 by the introduction of the lady beetle *Coccinella undecimpunctata* L. into New Zealand from England for the control of aphids. The next recorded movement was that of *Apanteles glomeratus* (L.), a parasite of the cabbage worm, to the United States from England in 1883. These three efforts resulted in establishment of the parasites in their new environment, but in no instance was economic control complete.

As mentioned above, the first example of complete and sustained economic control of an insect pest by a beneficial organism was the control of the cottony-cushion scale by the vedalia beetle. The cottony-cushion scale was accidentally introduced into California from Australia about 1869. It was first found on a species of Australian acacia in a nursery at Menlo Park, near San Francisco. None of the natural enemies of this scale were introduced with it. Free of any effective natural check, the scale spread rapidly over a large portion of the state. It was introduced on lemon trees from the nursery at Menlo Park into southern California, prior to 1876, and soon became a widespread primary pest of citrus. No means of chemical control proved effective against it. By the early 1880's citrus crops were being lost, trees were being ruined, and properties had depreciated in value.

In 1888, C. V. Riley, chief entomologist of the United States Department of Agriculture, arranged for Albert Koebele to go to Australia in search of enemies of the cottony-cushion scale. Within a few months, Koebele sent two species of insect enemies of the scale to California. These were the vedalia beetle and the parasitic fly, *Cryptochaetum iceryae* (Will.). Both species became established, but the vedalia beetle proved to be the more effective of the two. Within a year, orchards in which vedalia beetles were first released were practically free of the scale, and within two years the cottony-cushion scale ceased to be of economic importance in California.

Since the establishment of biological control of the cottony-cushion scale, many insect pests in various countries have been controlled by the biological method. The purposeful introduction into various parts of the world of certain entomophagous insects brought about full commercial control of their hosts. It is significant that in each case only one species of natural enemy was primarily responsible for control (*2*). The following list includes some of these insects:

Anaphoidea nitens Gir., a parasitic wasp (egg parasite), introduced from Australia to the Union of South Africa to control the eucalyptus snout beetle, *Gonipterus scutellatus* Gyll.

Apanteles solitarius (Ratz.), a parasitic wasp, from Europe to Canada and parts of the United States, to control the satin moth, *Stilpnotia salicis* (L.), a pest of certain forest and shade trees.

Aphelinus mali (Hald.), a parasitic wasp, from the eastern United States to New Zealand, Australia, and elsewhere, to control the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), a pest of apple trees.

Cyrtorhinus mundulus Bredd., a predaceous bug, from Fiji to Hawaii, to control the sugar-cane leaf hopper, *Perkinsiella saccharicida* Kirk.

Cryptognatha nodiceps Mshll., a lady beetle, from Trinidad to Fiji, to control the coconut scale, *Aspidiotus destructor* Sign.

Eretmocerus serius Silv., a parasitic wasp, from Malaya to Cuba, to control the citrus black fly, *Aleurocanthus woglumi* Ashby.

Prospaltella smithi Silv., a parasitic wasp, from China to Japan, to control the spiny blackfly, *Aleurocanthus spiniferus* Quaint., a pest of citrus.

Ptychomyia remota Aldr., a tachinid fly, from Malaya to Fiji, to control the coconut moth, *Levuana iridescens* B.-B.

Rodolia cardinalis (Muls.), a lady beetle, from Australia to California and to many other countries, to control the cottony-cushion scale, *Icerya purchasi* Mask., a pest of citrus.

Tretacnemus pretiosus Timb., a parasitic wasp, from Australia to California, to control the citrophilus mealy bug, *Pseudococcus gahani* Green, a pest of citrus.

Introduction of a parasite obtained from a pest species other than that to be controlled. It has been demonstrated in several instances that parasites obtained from a host species other than that to be controlled may be successfully utilized. An example of this is the control of the coconut moth, *Levuana iridescens,* in Fiji, through the introduction of a tachinid fly, *Ptychomyia remota,* a parasite of *Artona catoxantha* Hmps., a moth of a different subfamily. This highly successful biological control project has been reported in detail by Tothill *et al.* (*3*). In this instance the native home of the coconut moth was in question. However, *Artona,* a different moth pest of the coconut palm, was known to be controlled by parasites in Indo-Malaya. Consequently, two parasites of *Artona,* a tachinid fly and an ichneumonid wasp, were introduced into the Fiji Islands from Indo-Malaya. The tachinid *Ptychomyia* proved to be a very effective parasite of the coconut moth in Fiji. Field control of the pest was accomplished in many areas within six months after release of the parasites, and economic control was general throughout the islands within 2 years.

Biological races of parasites. Experience has shown that in many instances a single species of parasite may be represented by two or more races which are morphologically indistinguishable and yet show marked biological differences.

The parasitic wasp *Comperiella bifasciata* How. offers an outstanding example of a single parasite species comprising at least two morphologically indistinguishable races. Through a series of attempts to establish *C. bifasciata* as a parasite of the California red scale, *Aonidiella aurantii* (Mask.), a pest of citrus in California, it was learned that stocks introduced from China differed biologically from these introduced from Japan. Both races oviposit readily in the California red scale, but only the Chinese race of *C. bifasciata* can reproduce upon it; the Japanese race rarely completes its development in this scale. However, both the Chinese and the Japanese races of *C. bifasciata* reproduce readily in the closely related yellow scale, *Aonidiella citrina* (Coq.), which is also a pest of citrus in California (*4*).

The biological control program on the olive scale, *Parlatoria oleae* (Colvée), in California, serves as a more recent illustration of the importance of biological races of parasites in pest control. In this instance stocks of *Aphytis maculicornis* (Masi) imported in 1951 from the area extending from India through the Middle East to the Mediterranean proved to be indistinguishable morphologically, yet biological studies by Hafez and Doutt (*5*) revealed the existence among them of three races which have been designated as the Indian, Persian, and Spanish forms, and which show distinct biological differences. Under field conditions in California the Persian form has proved to be the most effective in the control of the olive scale. It is apparent that the success of a biological control project may depend on the importation of stocks of a beneficial species from the various parts of its geographic range; limitation of importation to a single source may preclude success.

Importation Procedures

The success of a biological control project involving the importation of beneficial insects requires the cooperative efforts of several well-trained entomologists. The work is generally divided into three phases: (i) importation, (ii) reception, and (iii) colonization.

The first step in the importation phase is the determination of the native habitat of the pest species, this being the most logical place to begin a search for its effective natural enemies. This involves assembling information on the distribution of the pest, of the plants on which it feeds, and of its natural enemies throughout the world. The sources of such information include agricultural journals, scientific publications, collections—those in museums and those of specialists—and files of unpublished data.

The foreign explorer, in order to ensure the proper handling of imported material, sends with each shipment all of the information he may have obtained regarding the environmental conditions under which the material was found and collected, the kind of host, and the relation of the material to other insects.

The reception phase involves the segregation and analysis of the entomophagus forms under quarantine conditions and the determination of their host relations. Properly constructed quarantine facilities and specially trained entomologists are essential for this phase of the work. Suitable quarantine housing is insect-proof and sturdy. It includes proper facilities for preventing the escape of insects, as well as facilities for the incineration of all introduced host-plant materials. All rearing areas are air-conditioned to ensure optimum conditions for rearing the insects. Space is available for housing all supplies and equipment needed to determine the host relations of the imported species and for their propagation in numbers sufficient for breeding stocks, pending their release from quarantine. The entomologist in charge should have the services of competent taxonomists for the gross identification of material. He should have special knowledge of insect biologies and rearing techniques and the ability to segregate and maintain cultures of biological races of parasites which are morphologically indistinguishable.

The colonization phase includes (i) the propagation of the selected species

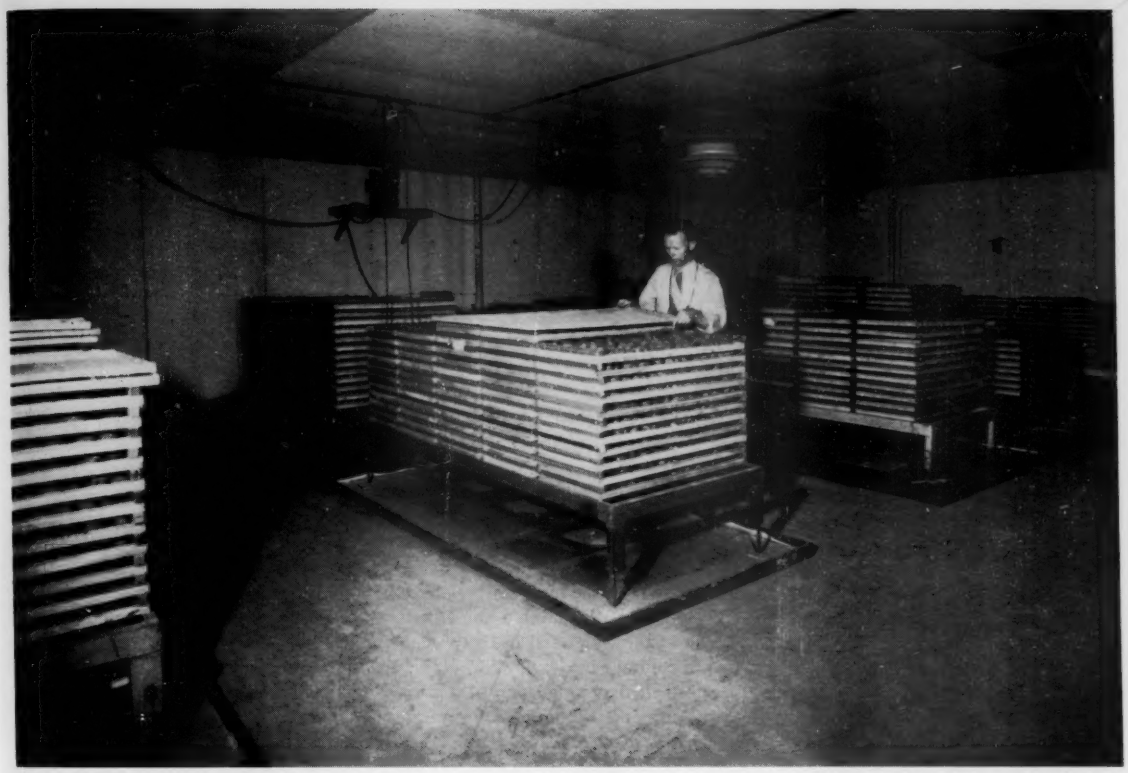

Fig. 1. Insectary room containing 50 stacks of wire trays, each tray holding 20 pounds of potatoes infested with tuber moth larvae that have been subjected to parasitization by *Macrocentrus ancylivorus* Roh. When the White Rose variety of potato is used, 75 to 80 percent of the host larvae are parasitized, the average pound of potatoes yielding 200 adult parasites. [After Finney, Flanders, and Smith]

in large numbers subsequent to release from quarantine; (ii) the selection of favorable spots for field release in all climatic areas where the pest occurs; and (iii) the ascertainment, should the beneficial species establish itself, of its effect on the population density of the host.

Mass Production and Periodic Release

It is reported that for centuries Chinese citrus growers have made a practice of placing colonies of predaceous ants in their orchards to protect the trees from the ravages of certain insect pests. The growers place bamboo poles from tree to tree to provide runways for these ants, and they feed them during certain periods when their hosts are scarce. In areas where it is too cold for the ants to overwinter, nests of these insects are purchased each spring from tradesmen in warmer areas who earn their livelihood by rearing these beneficial insects for fruit growers. In a discussion on the use of beneficial ants in China, Groff and Howard (*6*) cite a publication by Pei Wan Chai, dated 1708, which states that the kumquat is attacked by a "black ant" and that, in order to combat this ant, the people purchase "yellow ants" which they place in the trees. The "yellow ants" attack the "black ants" and kill them, and the trees thrive thereafter.

It was reported by Forskål in 1775 (*7*) and by Botta in 1880 (*8*) that predaceous ants were used in Yemen in southwestern Arabia to protect date palms from harmful ants. Each year the date growers of Yemen brought down from the mountains colonies of the beneficial ants and placed them in the palms to control the harmful ants.

In the United States, field-collected lady beetles have for many years been released for control of aphids infesting agricultural crops. The species of lady beetle that has been used almost exclusively in this work is *Hippodamia convergens* Guer. The beetles hibernate in compact colonies consisting of millions of individuals, in mountain valleys and canyons, and consequently can be collected in almost unlimited quantities at a low cost. The largest numbers of these lady beetles have gone to melon growers in the Imperial Valley of California. Recently, attempts have been made to utilize them on a large scale against the pea aphid, *Macrosiphum pisi* (Harris), in the eastern states, and against the green bug, *Toxoptera graminum* (Rond.), in the Middle West. However, in tests on the melon aphid, *Aphis gossypii* Glov., in the Imperial Valley, little or no benefit resulted from this practice, for the beetles dispersed widely immediately after release and generally appeared in the fields of their own accord as soon as the aphid infestation became sufficient to maintain them.

Predators and parasites. The instances in which naturally occurring populations of beneficial organisms can be collected and distributed periodically for economic pest control are rare. Of much more importance to the science of biological control has been the development of methods for the mass culture of beneficial organisms to be used in periodic release programs for pest control. The purpose

of such programs is primarily to increase the efficiency of native or established beneficial species which, for various reasons, are not fully effective in the field.

Mass-produced beneficial insects may also be used in the inundative method of pest control. In this technique, which is practicable only under exceptional circumstances, sufficient numbers of the beneficial species are released at one time to control the pest by the first field generation. In such cases the numbers released per unit area may far exceed the host population, as frequently occurred when the wasp *Macrocentrus ancylivorus* Roh. was used to control outbreaks of the oriental fruit moth in California during the period from 1944 to 1946 (*9*).

In the mass culture of any organism the basic problem is usually the economic mass production of its food. In the culture of beneficial insects, an obvious solution to this problem is the production of suitable quantities of host insects. The discovery at Sacramento, California, in 1916, that mealy-bug pests of citrus could be grown on potato sprouts paved the way for the first successful mass culture and periodic release of insectary-produced entomophagous insects (*10*). In this project the lady beetle *Cryptolaemus montrouzieri* Muls. was reared by the millions on mealy bugs grown on potato sprouts. The beetles were released in California citrus orchards at critical periods to control the mealy bug on citrus. The use of this beetle is today a part of the citrus pest control program in certain parts of California.

The potato has proved useful in other mass-culture projects. The sprouts have served exceptionally well for the production of black scale (a pest of citrus and other plants), permitting the economical production of millions of a series of imported parasites. The potato tuber itself is an excellent host on which to produce California red scale (a primary pest on citrus in California) and other related scales used in parasite production. The potato tuber also provided a means whereby many millions of the wasp *Macrocentrus ancylivorus* were produced for the control of the Oriental fruit moth outbreak in California (Fig. 1). This production was possible because the potato tuberworm proved to be an acceptable host for the parasite, although the latter is not known to attack the tuberworm in the field (*9*).

Ripe oranges, citron melons (*Citrullus* spp.), and banana squash have been used as food in the mass-rearing of several species of tetranychid mite pests, which, in turn, are used in the production of natural enemies of mites (*11*).

The first mass production of a parasitic hymenopteran for periodic release was that developed for propagating species of *Trichogramma* parasitic on the eggs of moths and butterflies (*12*).

In the early work on this project corn was used for rearing the host insect, the Angoumois grain moth, *Sitotroga cerealella* (Oliv.). From large numbers of moths economically produced by this method, eggs were obtained for the mass rearing of *Trichogramma*. With various modifications, such as the use of wheat instead of corn for rearing *Sitotroga*, this method of mass-producing *Trichogramma* is now being used by private insectaries in several countries.

In a number of instances artificial media have been used successfully in the mass culture of host insects, parasites, or predators. Hagen (*13*) found that egg deposition of the predator *Chrysopa californica* (Coq.) was greatly increased by adding an enzymatic hydrolysate of brewer's yeast to the honey solution fed to adults.

Hagen and Finney (*14*) recently developed an artificial food medium for the mass production of the oriental fruit fly, *Dacus dorsalis* Hendel, in Hawaii, which greatly expedited the parasite-production program. The use of fruit for this purpose was uneconomical, and it was impracticable for several other reasons. A preparation of squash, later replaced by carrot, supplemented with an enzymatic protein hydrolysate of soy to induce increased fecundity, proved highly satisfactory for large-scale production of the fly.

House and Traer (*15*) found that the larvae of the sarcophagid fly, *Pseudosarcophaga affinis* (Fall.), parasitic in the spruce budworm, *Choristoneura fumiferana* (Clem.), could be reared on an artificial medium. They showed that a proper mixture of pork liver and fish was fully acceptable to the parasite larvae and that a much higher proportion of the larvae reached maturity on this medium than on the natural insect host. This development permitted year-round production of the parasite in any desired quantity.

Insect pathogens. Mass-produced pathogenic microorganisms are also used in "mass-release" programs to control noxious insects. When employed in this manner the pathogens may be colonized in the field, or they may be mixed with a suitable diluent and applied as dusts or sprays. Such insect pathogens, being fairly specific, are harmless to other forms of life and thus have no adverse effect on the biological balance of other pest species in the area where they are used.

In 1911 the artificial distribution of a bacterium, *Coccobacillus acridiorum* d'Her., apparently controlled migratory locusts (*Schistocerca* spp.) in Mexico, Argentina, and Tunisia (*16*). This was the first well-publicized instance in which bacteria were used in an attempt to control insects.

The most outstanding example of insect pest control by mass-produced dis-

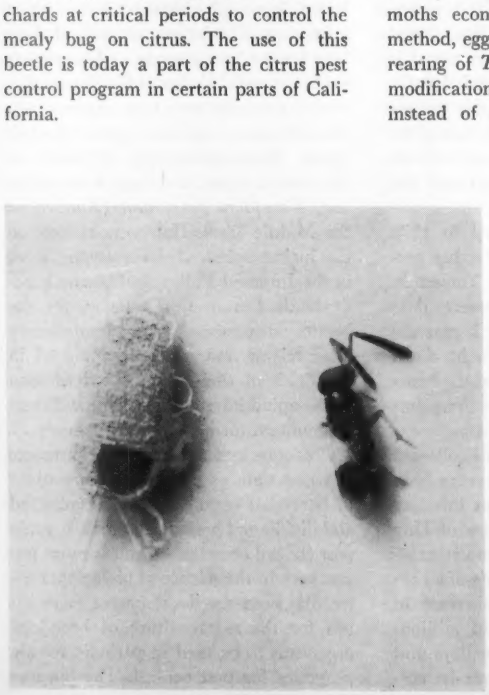

Fig. 2. Mummy of a long-tailed mealy bug (left) which was parasitized by *Anarhopus sydneyensis* Timb. (right). The circular opening in the mummy is the exit hole through which the parasite emerged. *Anarhopus sydneyensis*, introduced into California from Australia, controls the long-tailed mealy bug on avocado, citrus, and other plants.

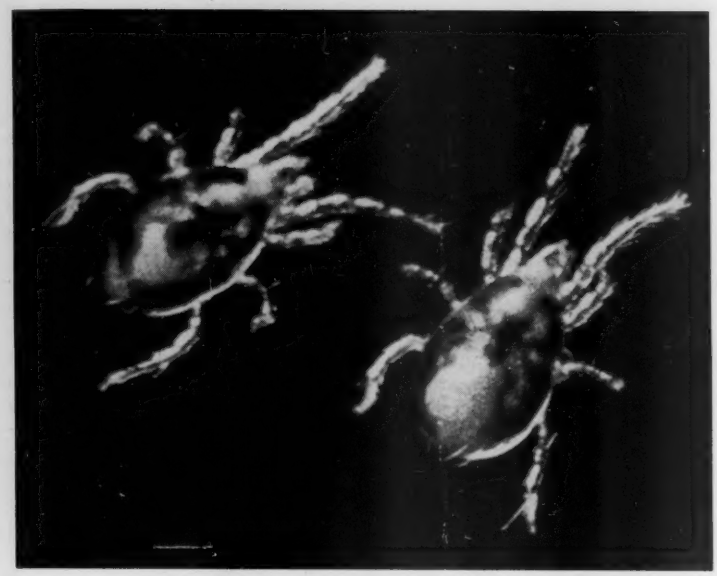

Fig. 3. Predatory mite, *Typhlodromus* sp. Mites belonging to this beneficial genus prey on many species of injurious plant-feeding mites.

ease organisms is the use of *Bacillus popilliae* Dutky, the causative agent of milky disease, against the Japanese beetle, *Popillia japonica* Newm., in the eastern United States. In 1939, members of the Bureau of Entomology and Plant Quarantine of the U.S. Department of Agriculture devised methods for preparing spores of *B. popilliae* for field distribution (*17*). In this preparation spores of *B. popilliae* cultured in Japanese beetle larvae are mixed with a suitable carrier, such as talcum powder, at a concentration of approximately 100 million spores per gram. This spore-dust mixture is applied to the soil, and the spores are disseminated throughout the area. The Japanese beetle larvae, which subsequently ingest the spores, are then destroyed by the well-known milky disease.

Insect pathogens, as well as parasites and predators, may be mass-produced on artificial media. The famous Russian zoologist Elie Metchnikoff was probably the first to produce an insect pathogen on an artificial medium. In 1880 he utilized sterilized beer mash for the production of spores of the green-muscardine fungus *Metarrhizium anisoplae* (Metch.). The spores thus produced were used experimentally in the control of several insect pests (*18*). The bacterium *Coccobacillus acridiorum,* used by d'Herelle to control locusts, was produced on nutrient agar. In the 1920's and early 1930's several European workers used aqueous suspensions and dusts of the bacterium *Bacillus thuringiensis* Berliner with varying degrees of success in controlling the European corn borer, *Pyrausta nubilalis* (Hbn.). In California, in 1950, spores of *B. thuringiensis* produced on nutrient agar were used in field experiments on the biological control of the alfalfa caterpillar, *Colias philodice eurytheme* Bdv. (*19*). The results of these experiments and of experiments involving the use of *B. thuringiensis* to control other lepidopterous pests were so promising that this material is now being produced commercially in aerated nutrient broth by several firms.

Although at present the number of beneficial organisms which can be produced on artificial food media is limited, it is apparent that in the study of nutrition lies one of the greatest frontiers in the science of biological control.

Conservation and Augmentation of Native Beneficial Organisms

Economic importance. Plant-feeding insects everywhere are subject to attack by parasites, predators, and diseases. In some cases the influence of these beneficial organisms on pest populations is merely superficial; in other cases their influence is of great economic importance. These beneficial organisms control many pest insects which, in their absence, would cause serious economic loss. In fact, the vast majority of plant-feeding insects throughout the world are under satisfactory natural balance. Control measures such as the use of insecticides are necessary only where effective beneficial organisms or other natural control factors are either lacking or unable to maintain pest species below the level of economic importance.

Results of long-term field studies on the biological balance in California avocado groves will serve to illustrate the great economic importance of native parasites and predators and the problems involved in their conservation.

Pest-control treatment is seldom necessary in California avocado orchards. Each year only a fraction of 1 percent of the total avocado acreage receives chemical pest-control treatment. Field studies now in progress have shown that, despite the seeming freedom from destructive pests, there are many species of insects of potential economic importance present in avocado orchards throughout southern California, but that in general they are in a state of almost perfect biological balance (*20*). Some of the potential pests—such as the long-tailed mealy bug, *Pseudococcus adonidum* (L.), the black scale, *Saissetia oleae* (Bern.), and the soft (brown) scale, *Coccus hesperidum* L.—are controlled by imported parasites, but most are controlled by native parasites and predators (Fig. 2). Numerous experiments have shown that when parasites and predators are excluded from avocado trees in any area, damaging populations of various mite and insect pests soon develop.

In one experiment, for a period of 84 days all parasites and predators were removed by hand from a portion of an avocado tree in an orchard in the coastal area of San Diego County. During this time the omnivorous looper, *Sabulodes caberata* Gn., the six-spotted mite, *Eotetranychus sexmaculatus* (Riley), the long-tailed mealy bug, the avocado brown mite, *Oligonychus punicae* (Hirst), and the latania scale, *Hemiberlesia lataniae* (Sign.), developed to high populations on the portions of the tree from which the beneficial insects were removed. The three first-named species developed to seriously damaging proportions (*21*).

To save the leaves on the experimental portion of this tree, it became necessary to remove the larvae of the omnivorous looper, whose population also

had been released from the repressive action of natural enemies. A careful study of the natural balance of the looper larvae at this time disclosed that over 90 percent of the very young larvae were parasitized by one or the other of two species of small wasps, *Apanteles caberatae* Mues. and *Meteorus tersus* Mues. These two native parasitic wasps were largely responsible for the excellent natural control of the loopers that was maintained in the orchard during these studies.

Throughout the entire experimental period there were no observed pest problems on the remainder of the test tree or on any other tree in the grove.

In this instance, predatory *Typhlodromus* mites (Fig. 3), a small black lady beetle (*Stethorus picipes* Casey), and a small staphylinid beetle [*Oligota oviformis* (Casey)]—all native predators—were primarily responsible for the control of the avocado brown mite and the six-spotted mite.

This simple experiment clearly demonstrated that except for the protective action of native parasites and predators the damage caused throughout the grove by the pests mentioned would have been truly disastrous.

Other such studies showed that when beneficial insects were removed by hand from certain castor-bean plants, the plants soon lost most of their leaves as a result of feeding damage by the two-spotted mite, while the surrounding plants remained relatively free of mites and showed practically no mite damage. Similarly, when predators of citrus red mites were removed by hand from certain citrus trees, those trees were much more seriously damaged by the mites than were surrounding trees to which the predators had access (*22*).

At Riverside, in the interior avocado-growing area of California, *Amorbia* (see Fig. 4) may quickly build up to seriously damaging populations when parasites and predators are excluded by the use of screen tree cages or cloth sleeve cages. Upon removal of such barriers excellent natural balance is attained in a surprisingly short time.

Ants. There are many species of ants associated with agricultural crops. Some of the ants prey on harmful insects and thus are beneficial; others inhibit the activity of beneficial insects or damage plants and thus are harmful.

The use of predaceous ants in China to control various citrus pests and in Arabia to control ants destructive of date palms has already been discussed.

In the forests of Germany, ants of the genus *Formica* are colonized in artificial nests and protected for their aid in controlling insect pests of the trees. There are many other species of predaceous ants which, in the aggregate, destroy vast numbers of noxious insects; the economic value of ants in this respect seems to have been generally underestimated.

The species of ants that are harmful to agricultural crops are mainly those that feed on honeydew secreted by scale insects, mealy bugs, white flies, aphids, and leaf hoppers. Their activities emphasize the importance of entomophagous insects in pest control. In gathering honeydew, ants surround these pest species and attack other insects that attempt to reach them. In this way they protect the harmful species from their insect enemies and make it possible for the former to thrive and increase to the point of causing severe damage. This protective effect is not limited to honeydew-producing species but is often extended to associated phytophagous species such as mites and diaspidine scale insects, when such forms happen to be within the area of ant activity.

In avocado orchards in California the Argentine ant, *Iridomyrmex humilis* Mayr, while gathering honeydew from colonies of long-tailed mealy bugs, soft (brown) scale, and black scale, protects these pests from their natural enemies and thus is frequently responsible for the development of damaging populations of the pest species. This same ant also disturbs or kills natural enemies of other pest species in the vicinity and is therefore frequently responsible for increasing the populations of such non-honeydew-secreting pests as six-spotted mites, avocado brown mites, and *Latania* scale. The Argentine ant has a similar influence on insect pests in California citrus groves. Therefore it is essential to eliminate ants from orchards where biological control measures are practiced.

It is becoming increasingly clear that the presence of honeydew-feeding ants may greatly reduce the effectiveness of beneficial insects that might otherwise be capable of controlling major pest species, regardless of the pest or the plant species concerned.

Insecticides. Just as the removal of beneficial insects by hand-picking or through the use of mechanical barriers may result in the development of heavy infestations of their harmful insect hosts, so may a similar result follow the use of insecticides which are toxic to beneficial species. In this manner a given insecticidal treatment may result in (i) an increase in numbers of the pest species against which control is directed, or (ii) serious outbreaks of other insects and mites, which, prior to the treatment, were so rare as to be of no economic importance.

In the first case, the pest increase occurs because the insecticide that effectively controls the pest for a given period of time has an even more drastic and longer-lasting effect on the beneficial species which formerly gave partial control of the pest. Thus, freed of natural enemies, the pest species rapidly increase to much higher populations than occurred before treatment.

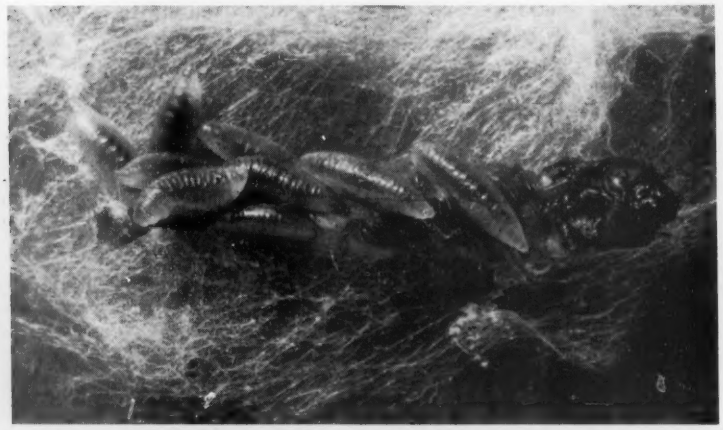

Fig. 4. Larvae of a parasitic wasp, *Elachertus proteoteratis* Howard, devouring a caterpillar of *Amorbia essigana* Busck, a pest of avocado in California. This native parasite, along with several other native parasites, effectively controls *A. essigana*.

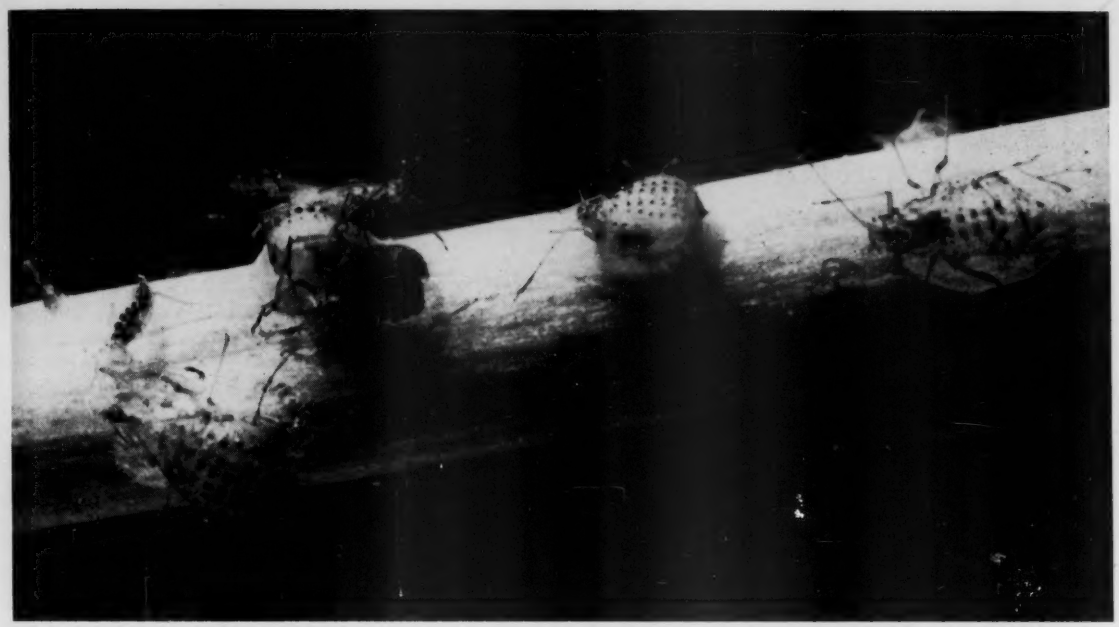

Fig. 5. Spotted alfalfa aphids parasitized by the wasp *Praon palitans* Mues. Cocoons of the wasp may be seen securely attached between the dead aphids and the alfalfa stem. *Praon palitans* was introduced into California from the Middle East.

In the second case, the pest species may increase in numbers either for the same reason as given in the first case or because the treatment killed certain beneficial species but was innocuous to the pests which these species had controlled. Entomological literature contains many examples of these several effects of insecticides on biological balance.

Biological upsets following the use of insecticides have been especially common since the relatively recent development and widespread use of highly toxic insecticides having long residual action. DDT was the first of the new insecticides to attract attention in this respect. The extensive and indiscriminate use of DDT destroyed harmful and beneficial insects alike and resulted in a subsequent increase in numbers of phytophagous insects and mites. For example, DDT readily killed all arthropod enemies of certain plant-feeding mites but did not kill the mites; consequently, many agricultural crops developed injurious mite populations following the use of DDT for the control of various insect pests.

An excellent example in this connection was the severe damage caused by six-spotted mites in California avocado orchards following the use of DDT for control of the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché). DDT gave excellent control of the thrips, but it also killed the natural enemies which had previously controlled the six-spotted mites. Thus freed of their natural check, the mites, which were not harmed by the DDT, rapidly increased in numbers and severely damaged the trees. This particular danger is now avoided by the use of a modified spray program.

In addition to the potent new insecticides, there are various other pest-control materials which have long been known to cause biological upsets. In a recent review of the effects of pesticides on arthropod populations, Ripper (*23*) states that in spite of a good initial kill at the time of treatment, chlorinated hydrocarbons, parathion, para-oxon, sulfur, lime sulfur, copper carbonates, calcium arsenate, derris, zinc sulphate, thiuram, and even supposedly inert materials used on orchard or field crops at times bring about a tremendous increase of the pest species against which they have been applied or of other phytophagous species present in small numbers at the time of treatment. Upsets of this sort have been recorded in temperate, subtropical, and tropical climates for many species of arthropods belonging to the families of Tetranychidae, Euophyidae, Tarsonemidae, Coccidae, Aphididae, Aleyrodidae, Cicadellidae, Noctuidae, Tortricidae, Olethreutidae, Tephritidae, Agromyzidae, and Collembola.

Because the indiscriminate use of insecticides frequently results in the destruction of beneficial insects and thus in increased rather than in decreased pest activity, and because both insecticides and beneficial insects play important roles in pest control, more and more attention is being given to the development of integrated pest-control programs. The aim of such programs is the development of insecticidal treatments which will least inhibit the activity of beneficial insects. Considerable progress is currently being made in this respect through the use of selective insecticides, proper timing of application, and proper insecticidal dosage.

The recent program developed for control of the alfalfa aphid, *Therioaphis maculata* (Buckton), in California, offers an excellent example of integrated pest control (*24*). In this program the use of Systox—a selective systemic insecticide—with proper timing and a low dosage, offered a minimum of resistance to a complex of native and introduced beneficial organisms, including parasites (see Fig. 5), predators, and diseases. The activity of beneficial organisms in this integrated pest-control program now saves millions of dollars annually for California alfalfa growers.

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CURRENT PROBLEMS IN RESEARCH

Electroluminescence

New light sources, having theoretical as well as practical interest, are created by electroluminescence.

K. H. Butler

The art of producing light has gradually evolved from the original volume sources, typified by a bonfire or a lamp flame, through line sources, represented by incandescent filaments, to point sources, such as the concentrated arc lamp, and finally to a plane source, the electroluminescent lamp.

This newest member of the large family of lamps generates a sheet of light, not more than a few thousandths of an inch thick, by direct electrical excitation of a phosphor embedded in a dielectric layer. This light-emitting surface can be applied directly to a thin piece of metal, giving a lamp no thicker than half a dozen pages of a magazine, with two fine wires leading to a source of power. The simplicity and mechanical strength of the electroluminescent lamp thus presents a striking contrast to the complex supporting structure and fragile glass envelopes of practically all other electrical lamps.

While natural phosphorescent materials must have existed for many thousands of centuries, no known record exists prior to A.D. 980, when it was noted by the Japanese that calcinated oyster shells could store up light by day and give it off at night. After several more centuries other materials were recognized which would convert ultraviolet radiation, or other special sources of energy, into visible fluorescent light immediately. The systematic studies by Becquerel, Lenard, and Nichols between 1860 and 1920 laid the foundations for the modern development of phosphors.

While phosphors are generally excited by bombardment with high-speed electrons, as in television tubes, or by ultraviolet radiation, as in the fluorescent lamp, many other methods can be used to make them luminesce. However, the results are usually only of scientific interest and have no practical value.

In the early 1920's Gudden and Pohl made some noteworthy studies of the luminescence and photoconductivity of zinc sulfide phosphors. In the course of these investigations they found that if a phosphor were excited by ultraviolet radiation, the application of a strong electric field during the phosphorescent decay gave a temporary increase of light emission. Further studies by Schmidt, Hinderer, and Destriau confirmed and extended this observation. Destriau reported also that a strong field applied to certain phosphors, without previous ultraviolet excitation, would give a transient light emission and that if the field were alternating, the light emission would be sustained.

This scientific observation remained essentially dormant until 1950, with some scientists doubting the existence of the effect, until Payne, Mager, and Jerome announced the development of a practical electroluminescent lamp in their report to the Illuminating Engineering Society. Commercial production of the lamp followed immediately.

The potential importance of this unique light source was obvious, and there has been a rapid burgeoning of interest in electroluminescence for the last ten years, with a proliferation of papers in many journals.

In the present article an attempt is made to winnow out and present the more significant facts on electroluminescence from the extensive literature.

Lamp Construction

Basically, the commercial electroluminescent lamp is a flat-plate condenser with the dielectric medium between the two electrodes containing a phosphor in suspension. When alternating current in the audiofrequency range is supplied, power consumption by the suspended particles results in excitation of the phosphor with emission of visible light. Since the light is generated in the dielectric phosphor layer, at least one of the electrodes of the condenser must be transparent or translucent to give a useful lamp.

Figures 1A, 1B, and 1C show three types of construction which have been used in manufacture during the last eight years. In type A, a sheet of glass is

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sprayed while hot with a solution of tin chloride. This treatment gives a conductive layer of tin oxide on the surface, and a display of interference colors in the film shows that the thickness is only a few microns. This conductive surface is coated with a suspension of electroluminescent phosphor in an organic dielectric, usually a thermosetting type of plastic. The thickness of this layer varies from .001 to .005 inch, depending on the operating voltage of the lamp. The minimum value is limited by the size of some of the phosphor particles. A layer of white pigment in plastic is sometimes used over the electroluminescent layer to increase light output because of its high reflectance and to improve voltage breakdown. A back electrode is formed by evaporating aluminum on the organic layers. Contacts to the tin oxide film and to the aluminum film complete the lamp.

While this simple construction gives a useful lamp, an improved construction, described below, has several advantages. These are (i) greater ruggedness; (ii) greater ease of forming complex shapes; (iii) higher breakdown strength, which minimizes localized arcing at large phosphor particles; (iv) elimination of the tendency to carbonize and form a permanent conductive path, if arcing occurs; (v) elimination of evaporated aluminum and, as a result, of some adhesion difficulties between the aluminum film and the dielectric; and (vi) prevention of moisture penetration into the dielectric. Such penetration is generally followed by electrolytic decomposition of the phosphor to give free zinc, with resultant darkening accompanied by a rapid loss of light output.

With organic materials the problem of localized arcing is quite severe for 120-volt lamps, which require a very thin dielectric layer. The short life due to moisture-vapor penetration is more serious and demands, for adequate solution, an additional plastic coat on the back of the lamp to protect the aluminum film, plus a thick wax coating and a sheet of metal or glass behind the wax for mechanical protection. These preservative measures increase the lamp thickness to 3/16 inch, so that the many obvious advantages of a thin sheet of light are lost.

The use of a low-melting glass for the dielectric in which the phosphor is suspended has eliminated many of the complexities encountered with organic dielectrics and has led to type B and C constructions. In type C, a sheet of steel, preformed to the desired shape and size, is coated with a layer of powdered glass of special composition which is fused by heating to a continuous layer. A second coat, consisting of a mixture of the electroluminescent phosphor and ground glass, is applied and fused to the powdered coat. After removal from the furnace, the top surface is sprayed with a tin chloride solution to provide a conductive film. Finally, a clear glass coat is fused over the layers. Since the figure is not drawn to scale, it may be of interest to tabulate layer thicknesses for a typical type C lamp (Table 1).

Table 1. Layer thickness for a typical type C lamp.

Layer	Thickness (10^{-3} in.)
Sheet steel	20.0
Ceramic ground coat	1.5
Phosphor in ceramic	1.5
Conductive film	0.05
Ceramic glaze coat	1.0
Total thickness	24.05

Moisture vapor cannot penetrate glass layers for more than a few microns, so the problem of short life due to phosphor decomposition is nearly eliminated. Glass is conductive when very hot, but the conductivity vanishes on cooling; hence, no permanently conductive paths are formed, even if temporary arcing, due to severe overvoltage, occurs.

Type C lamps are in commercial production, and Fig. 2 shows a typical lamp, together with the clock for which it provides an illuminated face. Type B lamps have specialized uses in various devices which are discussed below.

In addition to these types of construction, some progress has been made toward development of a flexible lamp, where the phosphor is embedded in a thermoplastic resin and electrodes are applied to both sides of a thin sheet. A useful flexible lamp would require formation of a translucent conductive electrode through which the light would be emitted and elimination of moisture penetration into the plastic, which causes short life.

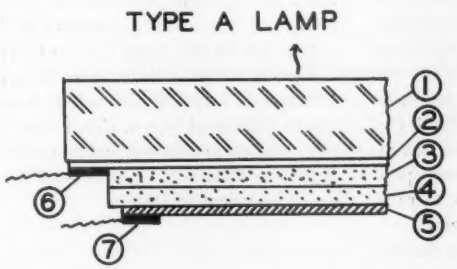


Fig. 1A. Construction of type A lamp: 1, glass; 2, conductive film of tin oxide; 3, phosphor in plastic dielectric; 4, TiO_2 in plastic dielectric; 5, evaporated aluminum; 6, silver paste contact, fused to surface; 7, silver paste contact, air-dried.

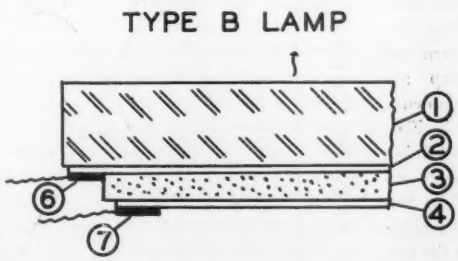


Fig. 1B. Construction of type B lamp: 1, glass; 2 and 4, conductive films of tin oxide; 3, phosphor in ceramic dielectric; 6 and 7, silver paste contacts, fused to surface.

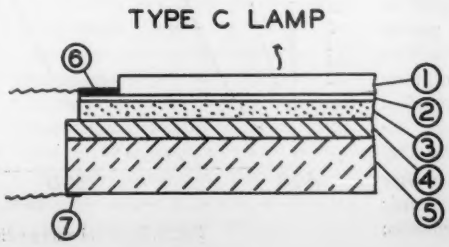


Fig. 1C. Construction of type C lamp: 1, transparent ceramic glaze; 2, conductive film of tin oxide; 3, phosphor in ceramic dielectric; 4, white ceramic ground coat; 5, metal sheet; 6, silver paste contact, fused to surface; 7, soldered contact.

Lamp Characteristics

Since the electroluminescent lamp is an alternating-current device, it can be operated with a wide range of frequency, voltage, and wave form. The amount and color of the emitted light, though primarily determined by the phosphor, are also influenced by the dielectric medium and the power applied.

The best electroluminescent phosphors available at present, showing reasonable efficiency in generating light, are zinc sulfides activated by copper. Control of the copper content allows either blue or green emission to be obtained at will. Addition of manganese, in increasing amounts, gradually suppresses emission at the shorter wavelengths, with concomitant development of emission at longer wavelengths in the yellow-orange portion of the spectrum.

Figure 3 indicates the variation in the spectral energy distribution of the emitted light for three typical phosphors. Other colors can be obtained by overcoating the lamp (by this means an organic phosphor will give excellent reds) or by using phosphors modified by the addition of selenium. These particular energy distributions are obtained with specific phosphors when the lamp is operated at 400 cycles per second. As the alternating-current frequency increases from 100 to 1000 cycles per second, the emitted light changes color, emission at short wavelengths being more pronounced. At higher frequencies, there is little or no additional color change.

In further discussion of lamp characteristics the behavior of green lamps will be indicated, since blue and yellow lamps generally show a parallel behavior, though with some minor variations. The surface brightness and total light emitted by an electroluminescent lamp are strongly dependent on both frequency and voltage applied, as shown in Figs. 4 through 7. It would be more precise, though less convenient in practice, to say that the brightness at a given frequency is determined by the voltage gradient or electric field between the two parallel electrodes. In manufacture, electroluminescent lamps are designed to withstand a voltage either 25 percent above their rated voltage or 100 volts above rated voltage. Because of these two separate criteria, it is convenient to divide lamps into two classes, the first being low-voltage lamps for 120- to 250-volt operation, where the safety factor demands a rather low electric field with consequent lower brightness;

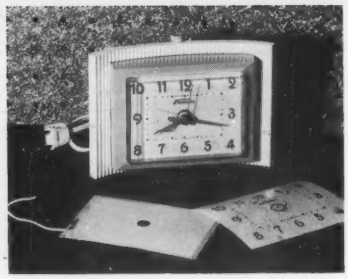


Fig. 2. Typical clock with lamp and overlay for lighted face. [Eric H. Muller]

the second being high-voltage lamps, for operation above 400-volts, where a higher electric field is possible and where greater brightness results.

Figure 4 shows data for a low-voltage lamp, while Fig. 5 gives data for a high-voltage lamp at selected frequencies. These curves of brightness can be represented by the equation

$$B = cf^a \exp(-bE^{-1/2})$$

where B is brightness in foot-lamberts (*1*); f is frequency in cycles per second; E is volts per mil of thickness; and a, b, and c are constants dependent on phosphor and dielectric properties (a is usually within the range 0.50 to 0.75).

Figures 6 and 7 indicate how the performance of a typical high-voltage lamp can be delineated by a modified form of this equation in which actual lamp voltage rather than field strength is used as the independent variable.

In addition to voltage and frequency, lamp temperature causes an appreciable change in light output, as is indicated in Fig. 8. It should be noted that the lamp brightness holds up well at low temperatures but begins to drop sharply when the temperature rises above 150°F. This sharp drop, combined with the low efficiency of the present commercial lamp, limits the useful operating range of such lamps to brightnesses somewhat below 100 foot-lamberts, unless provision is made for cooling the lamp.

As is mentioned above, the electroluminescent lamp has the character of a condenser, but with appreciable power consumption. This is brought out in the curves of Fig. 9, which show brightness, power factor, and current for a low-voltage lamp. The power factor is the ratio of watts, determined on an electronic wattmeter, to the product of volts and amperes, determined as root-mean-square values. Because of the distortion of wave shapes, phase-angle meters give very unreliable results if used for measurement of the power factor of these lamps.

The usual lumped-constant equivalent circuit will not adequately describe the electrical properties of the electroluminescent lamp, since both the capacity and the resistance appear to be nonlinear functions of voltage. Instead of a phase shift of the current with respect to voltage as the power factor changes, a distortion of the current wave shape occurs, with the gradual appearance of an in-

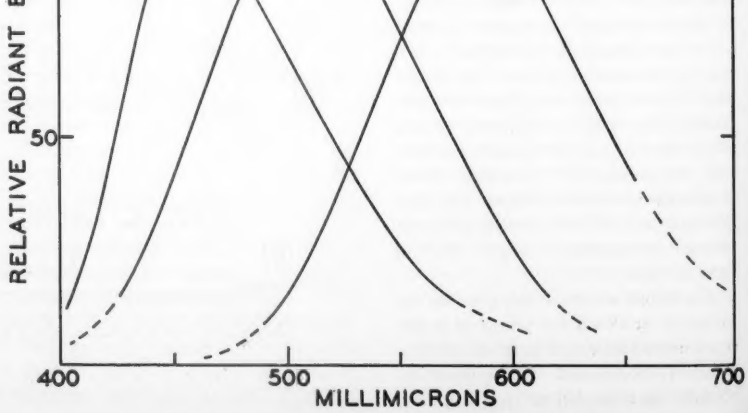
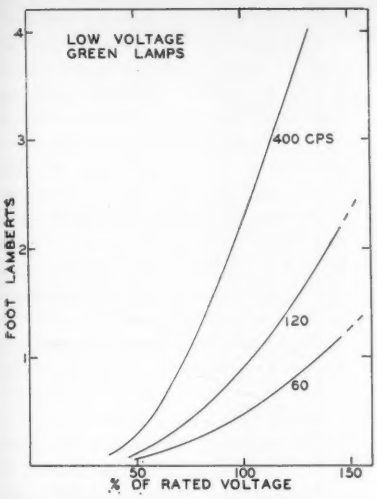


Fig. 3. Spectral energy distribution of typical phosphors.



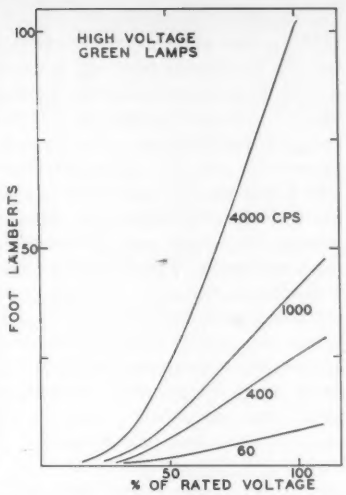


Fig. 4 (left). Variation of light output with voltage and frequency for 120-volt lamps.
Fig. 5 (right). Variation of light output with voltage and frequency for 600-volt lamps.

phase current component as the applied voltage is increased. The light output, however, remains nearly 90 degrees out of phase with the voltage and shows no phase shift, as the oscilloscope tracings of Figs. 10 and 11 show.

If, instead of a dual trace record, the oscilloscope is used to observe current as a function of instantaneous voltage, tracings like those of Fig. 12 are obtained. In this diagram the unshaded areas indicate when the lamp is absorbing power, while the shaded areas represent a release of stored energy. The resemblance to a B-H hysteresis (2) loop obtained with magnetic materials is rather striking, though field limitation rather than current saturation occurs, in contrast to the flux saturation at high field strengths evident with magnetic materials.

As an approximation, it is possible to consider an electroluminescent lamp as a nonlinear impedance, the relationship between current and voltage being $I = ZV^n$ ($n = 2$ to 3).

The efficiency of the commercial electroluminescent lamp considered as a light source is relatively low. Commercial lamps of type-C construction will normally have efficiencies of 1.0 to 2.0 lumens per watt in contrast to incandescent lamp efficiencies of between 10 and 20 lumens per watt and fluorescent lamp efficiencies of up to 75 lumens per watt. Design compromises can increase commercial efficiencies to 5 lumens per watt if power limitations require this. While, by designing for efficiency only, electroluminescent lamps of low surface brightness can be made with efficiencies up to 10 lumens per watt, when operated at optimum voltage and optimum frequency.

Solid-State Physics

Electroluminescence, like photoluminescence and photoconductivity, is a frontier region in solid-state physics where the experimental physicist has accumulated a mass of empirical information which is still awaiting an adequate interpretation. The modern theories of solid-state physics were given their first impetus by the need for an adequate explanation of conduction of metals. This need was met by the development of theories for the behavior of free electrons in the conduction band of a crystal lattice of metal atoms.

Every atom has certain fixed energy states (or energy levels) which its electrons can assume. These states can be grouped together in classes which, according to the Bohr theory of atomic structure, are related to the shape of the orbit. To select two examples, one class, the "s" electrons, has two energy levels; another class, the "p" electrons, has six energy levels. When a large number of atoms join together to form a crystal, the original energy levels shift somewhat, because of the interaction of the forces between atoms, so that the fixed energy levels of the separate atoms become an energy band in the solid. Since there are billions of atoms in a real crystal, the energy band contains billions of very closely spaced energy levels, but only one level per atom is present, corresponding with the one level per atom before formation of the crystal. These bands have, however, a fixed width of energy, determined by the particular atoms forming the solid and their arrangement in the crystal and not determined by the total number of atoms in a particular crystal. So we find an energy band for the "s" electrons and another energy band for the "p" electrons, containing $2N$ and $6N$ states, if there are N atoms in the crystal.

If the atoms making up the crystal do not contribute enough electrons to match the total number of available states in a given band, we have a partly filled band. In this case, an electron can gain a little energy and move into empty states in the band. When this occurs, the electron is no longer tightly bound to a particular atom but moves through the lattice freely, just as passengers in a partly filled railroad coach can move freely from seat to seat. One example of this type of solid is copper, where each atom has only one rather than the two possible "s" electrons, so that the "s" band is only half full. The electrons are free to move, and metallic conduction results in the solid.

If the number of electrons matches the number of available states, we have a filled band, and such materials are insulators. The analogy is a railroad coach with every seat filled, where only an interchange of position is possible, with no free movement.

In the individual atom we may have an electron in a given state; when the

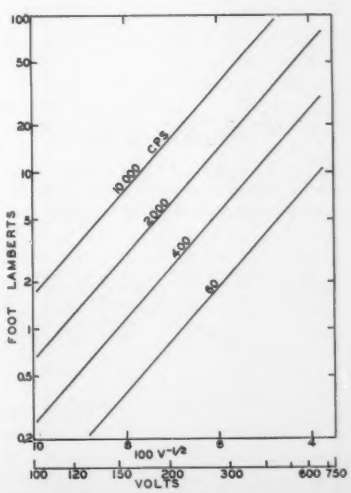


Fig. 6. Variation of light output, exponential equation representation with voltage being used as prime variable.

atom is excited with radiation of the right wavelength, energy is absorbed and the electron enters another state of considerably higher energy which is normally empty. The same phenomenon is possible in solids. By imparting sufficient energy to an electron in a filled band, it can be moved into an empty state in another band, called the conduction band. When this occurs the electron becomes free to move, and conduction results. The analogy is a passenger in a full coach moving into a second empty coach.

In some solids there is a definite energy gap between the various energy bands, which gives clearly defined and well-separated filled and conduction bands. In other solids, the bands are rather broad and overlap, so there is no energy gap; here conduction will occur even though there seem to be enough electrons to fill the band. Such is the case with zinc.

In a further development of solid-state theory, the behavior of rectifiers and transistors led to concepts of impurity states with nearly-free electrons which proved fruitful in the semiconductor field. In these materials the energy gap between the valence band and the conduction band is small, and the thermal energy of vibration at high temperature can give enough impetus to an electron to move it into the conduction band. This is true for pure germanium, which has four electrons but which shows a definite filled band and a conduction band separated by a small gap. If a few arsenic atoms, which have five electrons, are mixed with the germanium in the crystal, the extra electron is nearly free and provides a new energy state, the impurity level, just below the conduction band. Then, the amount of thermal energy needed to make the material conduct becomes minute, and we have quite good electrical conductivity even at room temperature.

Thus, important modifications in the original band theories were made when they were extended to semiconductors. In electroluminescent and photoluminescent materials, the energy gap is considerably wider, the concentration of impurities is much greater, and we are forced to consider the behavior of nearly-bound electrons requiring far more than thermal energy to release them into the conduction band. In these fields still further modifications of prior theories are being made, and electroluminescence can well serve as another steppingstone in the gradual development of solid-state theory.

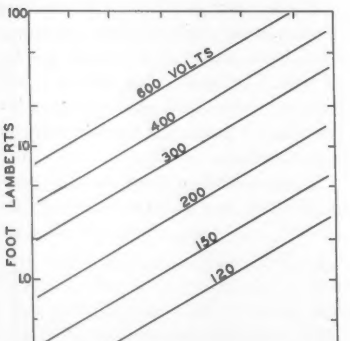


Fig. 7. Variation of light output, exponential equation representation with frequency being used as prime variable.

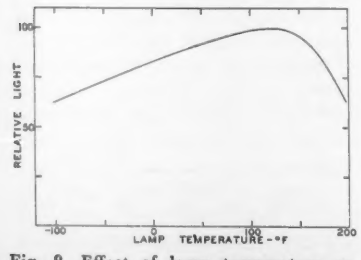


Fig. 8. Effect of lamp temperature on light output.

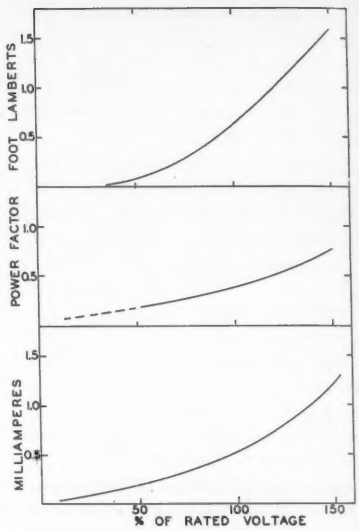


Fig. 9. Variation of light output, power factor, and current for a typical 120-volt lamp; area approximately 12 square inches.

Theory of Electroluminescence

The energy equivalent of green light is 2.4 electron volts, and it is very easy to show that simple acceleration of electrons in a uniform electric field cannot account for the usual type of electroluminescence. The usual electroluminescent lamp has a field of 100 volts per mil, or 4×10^{-4} volts per angstrom. Hence, a free path of 6×10^{3} angstroms would be required to accelerate an electron to the energy needed for light emission. Since this is 60 times the mean-free path of an electron in an ideal crystal of zinc sulfide, the ratio of the probable number of electrons reaching this energy to the total number of free electrons is given by $\log (n/n_0) = -60$. This infinitesimal number cannot possibly account for any light emission. Moreover, the number of electrons reaching the required energy would vary directly with the field E, while the observed light varies at $E^{\frac{1}{2}}$.

For a better explanation we can turn to the theory of rectifying junctions between metals and semiconductors. Here it is shown that migration of electrons and holes results in a space-charge barrier layer between the metal and the semiconductor and that most of the voltage drop occurs across this barrier layer. The thickness of the layer is given by $D = k(V_0/N)^{\frac{1}{2}}$, where V_0 is the potential drop across the barrier and N is the number of ionized impurity atoms. The field across the barrier becomes $E_0 = k_1 V_0^{\frac{1}{2}}$.

For particles in suspension in a dielectric, the voltage drop across a particle will be $V_0 = k_2 El$ where l is the length of the particle and E is the field in the dielectric. This voltage will be concentrated at the barrier layer. Thus, we arrive at the result that the barrier-field, E_0, which accelerates electrons, varies as the square root of the dielectric field, E. This is in agreement with experimental data on light emission where the exponent contains $E^{\frac{1}{2}}$ rather than E.

Evidence for the Theory

Consideration of the methods of phosphor synthesis and the results of microscopic observation of electroluminescent phosphors in a field lends added weight to the hypothesis of a barrier layer.

Electroluminescent zinc sulfides are frequently prepared by two firings. In

the first firing the activator and coactivator are introduced; this gives a material with excellent photoluminescence but little or no electroluminescence. This material is treated in any one of a variety of ways and refired to give an electroluminescent phosphor. After this second firing, the body color of the material is much darker, suggesting formation of a surface layer of differing composition. Microscopic examination of electroluminescent phosphors shows that the light is not generated all through the particle but rather at localized spots near the surface.

While we have a qualitative hypothesis, which seems reasonable, much work is needed before a firm quantitative theory can be developed on which everyone is agreed. Some of the disputed points are: What are the compositions of the layers on either side of the barrier? Are the layers *n*-type or *p*-type semiconductors? What are the depths of the energy levels below the conduction band? How thick is the barrier layer? What are the electrical properties of semiconductors suspended in a dielectric and how do barriers affect these properties? How efficient is the mechanism of electroluminescence and where do losses occur?

Many approaches to disputed points are being attempted, involving precise experiments on macroscopic crystals, on powders in suspension in various media, and on microscopic particles, either single crystals or polycrystalline particles. New techniques for micromanipulation, for pulse excitation with high voltages, and for measurement of minute amounts of light and of current are being developed. With the various attacks an adequate theory should soon be evolved, serving to guide further research and development.

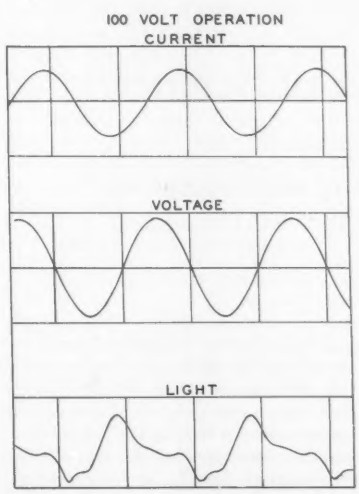
Applications of Electroluminescence

In spite of the recent advent of the electroluminescent lamp and of the competition from older, well-established light sources, the unique properties of the lamp have already generated numerous uses.

The uniformity of brightness over large areas, combined with extreme thinness, makes the lamp nearly ideal for various lighting uses, such as clock dials, instrument dials, radio panels, aircraft control panels, telephone dials, darkroom safelights, highway signs, and special decorative lighting.

The type-B construction, shown in Fig. 1, can be modified in a variety of ways by breaking up the conductive films into bars or other selected areas. This leads to uses for alpha-numerical indicators, where selected elements of a matrix area are switched to form a numeral or letter. In other applications, it is possible to select and light any one of the *mn* elements by using a cross-grid arrangement in the conductive films such that one film is broken into *m* parallel bars and the other into *n* bars.

The type-B construction also lends itself to devices using electroluminescence in conjunction with photoconductive control. If there is no feedback of light generated in the electroluminescent layer, the device can be used as an image converter, by means of which an x-ray image, an ultraviolet image, or an infrared image projected on the photoconductor generates a replica in visible light on the electroluminescent panel; if visible light is used, we obtain a light amplifier. If feedback is allowed, with provision for localization to discrete areas, light-storage devices can be made in which a momentary pulse of light will cause a selected element in an array to



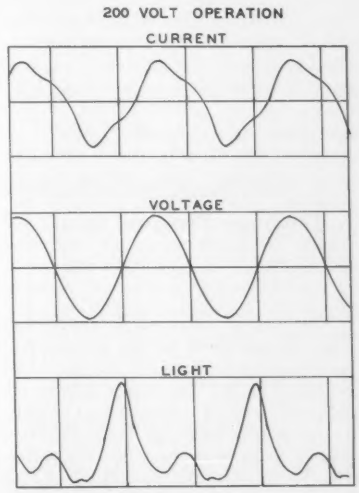


Fig. 10 (left). Oscilloscope traces of current, voltage, and light output for a lamp operated at 40 percent of rated voltage. Fig. 11 (right). Oscilloscope traces of current, voltage, and light output for a lamp operated at 80 percent of rated voltage.

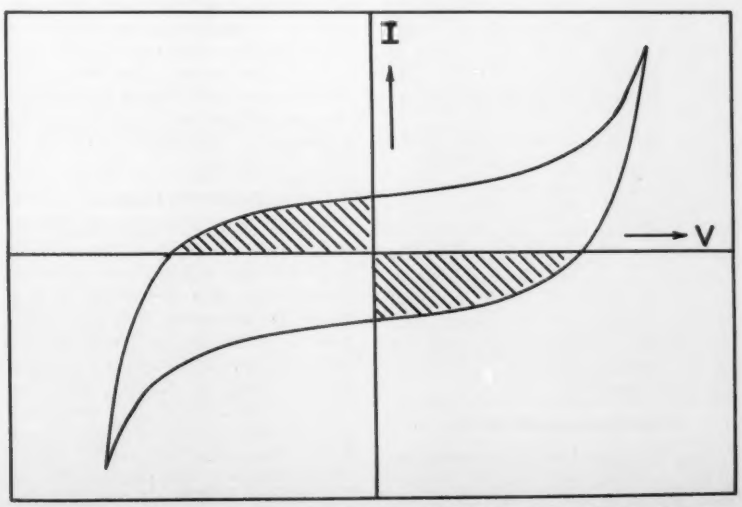


Fig. 12. Voltage-current trace of a typical lamp displayed to give a Lissajous figure.

light and remain lit indefinitely. By further modification the element can be triggered to the lit condition by a pulse of voltage superimposed on the holding voltage and, when desired, can then be turned off by another voltage pulse.

Conclusion

As this brief review indicates, electroluminescence is a true frontier in science and technology, now being explored as a new development in solid-state physics, as a new and useful light source, and as a new tool for development of information displays.

Notes

1. A foot-lambert is a measurement of brightness of a surface emitting light. It is equal to a foot-candle, which is a measure of the light incident on a surface. The usual fluorescent lamps have surface brightness up to 2500 foot-lamberts. Room illumination ranges from 5 to 50 foot-candles.
2. Hysteresis is a phenomenon occurring in the magnetization of steel where the change in magnetization lags behind changes in the field creating the magnetization.

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News of Science

American Oceanography Survey and Proposals for Ten-Year Program Made by NAS–NRC Committee.

The state of American oceanography today and its needs for the future have been assessed by a committee on oceanography of the National Academy of Sciences–National Research Council. The picture is dark now, the committee reports, and will be black by 1970 unless a major effort—a doubling of our deep-sea research during a ten-year program—is undertaken soon. Such a program would cost $651.5 million. According to a spokesman for the committee, the program may be expected to be well received on the grounds that oceanography is viewed by top government science planners as one of the three fields of greatest concern in the next decade. The other two are meteorology and nuclear physics.

This information was made public with the release of the first chapter—"An Introduction and Summary of Recommendations"—of an extensive report to be published later under NAS–NRC sponsorship. The report represents the committee's work since its establishment in 1957 by Detlev W. Bronk, president of the Academy–Research Council. Harrison Brown, professor of geochemistry at the California Institute of Technology, is the chairman.

Principal Recommendations

The three principal recommendations of the committee were that the Government should expand its support of the marine sciences at a rate which will result in at least a doubling of basic research activity during the next ten years; that this expansion should be accompanied by a new program of ocean-wide surveys twice as large as the present one; and that the support of the applied marine sciences should also be expanded, particularly in the areas of military defense, marine resources, and marine radioactivity. These recommendations were coupled with the warning that "action on a scale appreciably less than that recommended will jeopardize the position of oceanography in the United States relative to the position of the science in other major nations, thereby accentuating serious military and political dangers, and placing the nation at a disadvantage in the future use of the resources of the sea."

Reasons for Urgency

A note of urgency runs through the committee's report. In addition to the basic fact that oceanography is an important field that should not be neglected, the committee feels that it will have great bearing on future military and political relationships. It is the committee's view, for example, that "the submarine armed with long range missiles is probably the most potent weapon system threatening our security today." Other benefits of the program, the report states, would be a fuller utilization of the sea's resources, especially in the matter of providing animal protein for the underfed peoples of the world, and a better understanding of the origins and evolution of the planet.

Need for Ships

The ten-year program will require considerable increases in manpower and facilities, the committee reports. Stating that ships are to the oceanographer what cyclotrons or reactors are to the nuclear physicist, the report undertakes to map out a detailed program for the construction of a fleet of research ships which, by 1970, would give the United States a total of 85 oceanographic vessels. The present total is 45, of which number only 25 are classified as "principal oceanographic ships" in an article in *Research Reviews*. The committee's recommendations call for the construction of 70 ships of 500- to 2200-ton displacement between 1960 and 1970 at a total cost of $213 million. New ships are required, the committee states, because conversion of existing surplus vessels to oceanographic duties has been found to be uneconomical and unsatisfactory. Although not specifically mentioned by the committee, there is a competition under way in the field of oceanographic research vessels. The Russians and the Japanese are continually building to improve their fleets. One comparison illustrates the problem. In 1957, the U.S.S.R. commissioned the *Mikhail Lomonosov*, a fully equipped research vessel of 5960-ton displacement. The largest United States ship in the field is the *Spencer F. Baird*, a converted seagoing tug, built in 1944 and displacing 505 tons.

Need for Men

The committee advocated the broadening of educational opportunities in oceanography for graduate scientists through action by universities, the Federal Government, and the scientific community at large. This might be accomplished, the report stated, by increasing the size of oceanographic faculties, by

affiliating oceanographic research institutions with university faculties, by developing new oceanographic centers at universities with adequate existing faculties, and by creating long-term fellowships tenable at more than one university. The Government would be asked to aid in the financing of the recommended faculty increases to the amount of $500,000 a year for salaries and other costs associated with the positions. The scientific community would be asked to undertake more active recruiting of prospective oceanographers among undergraduate students of physics, chemistry, biology, and geology.

Need for Money

To meet the cost of its recommended ten-year program the committee has suggested a funding arrangement based on the relative importance of the program to the various federal agencies. The committee's recommendations are as follows: The Navy and the National Science Foundation should each finance about 50 percent of the new basic research activity, except for ship construction. The Navy should finance 50 percent of the new research-ship construction, with the Maritime Administration and the National Science Foundation sharing the remainder. The Navy, through the Hydrographic Office, should finance 50 percent of the deep-ocean surveys, while the Coast and Geodetic Survey should finance the balance. The Navy should sponsor completely all military research and development operations. The Bureau of Commercial Fisheries should finance the greater part of the recommended ocean resources program. The Atomic Energy Commission should finance the major part of the research dealing with the problems of radioactive contamination of the oceans. The National Science Foundation and the Office of Education should sponsor jointly the proposed program for increasing scientific and technical manpower in the marine sciences. Efforts aimed at fostering international cooperation in the marine sciences should be sponsored by the Department of State, the International Cooperation Administration, and the National Science Foundation. Other agencies should take responsibility for certain aspects of the proposed program, particularly the Public Health Service, the Geological Survey, and the Bureau of Mines. Although the bulk of oceanographic research and survey work must of necessity be financed by the Federal Government, the importance of state and private funds cannot be overestimated. Such funds are especially helpful for supporting initial exploratory basic research and for starting new laboratories.

Committee Membership and Support

The committee on oceanography is supported by the U.S. Atomic Energy Commission, Bureau of Commercial Fisheries, National Science Foundation, and Office of Naval Research, and is comprised of the following members, representing varied fields of interest: Harrison Brown, professor of geochemistry, California Institute of Technology (chairman); Maurice Ewing, director, Lamont Geological Observatory, Columbia University; Columbus O'D. Iselin, retired director, Woods Hole Oceanographic Institution; Fritz Koczy, professor at the Marine Laboratories, University of Miami; Sumner Pike, Lubec, Maine, formerly commissioner, U.S. Atomic Energy Commission; Colin Pittendrigh, professor of biology, Princeton University; Roger Revelle, director, Scripps Institution of Oceanography; Gordon Riley, professor at the Bingham Oceanographic Laboratory, Yale University; Milner B. Schaefer, director, Inter-American Tropical Tuna Commission; and Athelstan Spilhaus, dean of the Institute of Technology, University of Minnesota.

Other Events in Oceanography

In September of this year a major conference will be held on oceanography. This is the International Oceanographic Congress, sponsored by the American Association for the Advancement of Science. To be held at the United Nations building in New York, this congress will study all of the marine sciences during a 13-day meeting. In another development, the Scripps Institution of the University of California has begun a major survey of the Gulf of California. Two institution vessels, the *Horizon* and the *Spencer F. Baird*, are participating in the cruise, tentatively designated as the Vermilion Sea Expedition. The study will extend through May.

The Great Challenge

The CBS Television Network has announced that the 1959 "Great Challenge" series of 1-hour symposium-discussions is again directed towards appraisal of democratic institutions in a time of great scientific and technological advance. All programs are broadcast on Sunday afternoons from 2:30 to 3:30 EST. Eric Sevareid of CBS News is the moderator. The first program, which was shown on 22 February, was called "Where Is Science Taking Us?" and included J. Robert Oppenheimer, Detlev W. Bronk, and Jerome B. Wiesner. Other subjects and a partial list of participants follow:

1 March, "Is America Anti-Intellectual?" with Robert M. Hutchins, president of the Fund for the Republic and former president of the University of Chicago; J. Kenneth Galbraith, professor of economics, Harvard University, and McGeorge Bundy, dean, Faculty of Arts and Sciences, Harvard University.

22 March, "Can Democracy Meet the Space Age Challenge?" with Senator John F. Kennedy; Arthur Larson, former presidential adviser and director of the Rule of Law Center, Duke University; and Clinton Rossiter, professor of history, Cornell University.

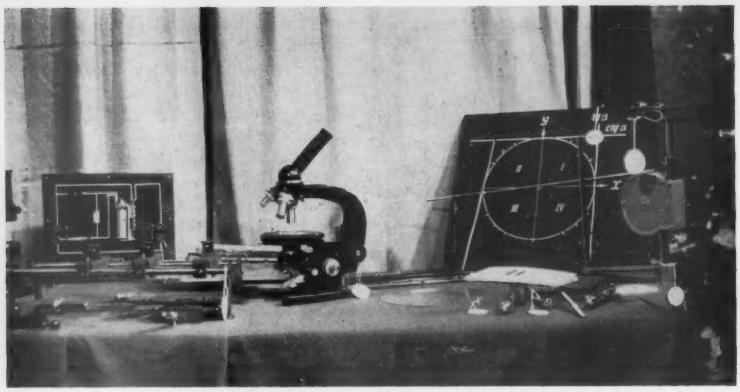
29 March, "Is American Journalism Meeting Its Responsibilities?" with Barbara Ward Jackson, a former editor of *The Economist* of London; J. Russell Wiggins, executive editor of the *Washington Post and Times Herald*, and former chairman of the Freedom of Information Committee of the American Society of Newspaper Editors; and John Fischer, editor in chief, *Harper's Magazine*.

5 April, "Is the American Public Getting the Information It Needs?" with James Reston, chief Washington correspondent, *New York Times;* Arthur B. Schlesinger, Jr., professor of history, Harvard University; Robert D. Swezey, executive vice president, WDSU Broadcasting Corporation, New Orleans, and chairman of the Freedom of Information Committee of the National Association of Broadcasters.

Soviet Teaching Equipment

Soviet equipment for science teachers has gone on sale in the United States; this is causing quite a stir, for American manufacturers are being substantially undersold. The equipment is being imported by the Ealing Corporation of Cambridge, Mass. (an affiliate of Baird Atomics, Inc.), which had an exhibit at the recent joint meeting in New York of the American Physical Society and the American Association of Physics Teachers. Ealing has selected 24 items out of a Soviet catalog of 96.

According to observers, the equipment, which is mass produced, is unusually well adapted to meet the special needs and problems of secondary-school teaching. On this subject, Sanborn C. Brown of Massachusetts Institute told the *Christian Science Monitor* that there has not been a really new item of high-school teaching equipment in American catalogs since World War II. He also said that many current items in this country date in design to the 19th century. Brown has made a thorough study of this subject, for he is chairman of the AAPT Committee on Apparatus for Educational Institutions. At the time of the



Soviet science teaching equipment

New York meeting, Brown made the following statement for the committee.

"American manufacturers of equipment for teaching physics in schools and colleges are moving to meet the challenge of Russian-produced equipment, but much remains to be done if the United States is to gain world leadership in this field. Not only a greater industrial effort is needed, but public support for physics laboratories should be increased as a part of the general strengthening of American education.

"Russian-built equipment for teaching physics in secondary schools is being exhibited by a commercial importer at the current meetings of the American Association of Physics Teachers and the American Physical Society. The Russian equipment is inferior in quality to the best equipment produced here, but it is better than much of the equipment in our smaller high schools. There is evidence that the Russians are prepared to sell such equipment at low cost in the tens of thousands of items for trade and propaganda purposes all over the world.

"The Committee on Apparatus of the American Association of Physics Teachers has encouraged American manufacturers of teaching equipment to produce high-quality physics apparatus. The committee made a market study two years ago, pin-pointing the items of equipment most needed by physics teachers. The results were made freely available to the apparatus industry. Expert consultants are available to the industry upon request. At the AAPT meeting this year, an apparatus contest with cash prizes has been arranged by the Committee to bring new forms of apparatus to the attention of teachers and manufacturers.

"American manufacturers are starting to respond to the demand for new and better apparatus. At the meeting now going on, approximately seven pieces of physics equipment not hitherto available commercially from U.S. companies are being exhibited. Several other pieces of equipment are being worked on and should soon be available. Although this indication of progress is encouraging and should be commended, much remains to be done. American physics teachers must be able to purchase top-quality lecture and laboratory apparatus if our physics students are to receive the best scientific education in the world. The Committee on Apparatus urges the apparatus industry to continue working toward this objective."

Manufacture of science teaching aids in this country is limited to a relatively small group of companies and protected by a steep tariff, the same tariff that is imposed on industrial apparatus. At one time equipment for educational purposes was exempt; but, partly through lobbying in Washington, the tariff was extended. The tariff has helped keep some reportedly excellent European equipment out of American schools.

Research Participation for Teacher Training

The National Science Foundation has announced the award of 56 grants totaling approximately $800,000 to 54 educational institutions for the purpose of conducting programs in research participation for teacher training in the summer of 1959. These programs will provide research experience for about 550 teachers of science and mathematics. About 400 of these will come from secondary schools; the remaining 150 will come from junior colleges and small colleges without appropriate research facilities. The foundation is supporting these experimental programs to provide further opportunities for teachers during the summer, in addition to the summer institutes for high-school and college teachers which has been so successful for several years and which will be continued this year.

Teachers will participate directly in scientific research in the laboratories of universities and colleges, or in field research programs, alongside experienced scientific investigators. This research experience will be supplemented by seminars and lectures on research methods and advances. Participating teachers will receive stipends of up to $75 per week plus allowances for travel and dependents. The programs will vary in length from 6 to 12 weeks.

Teachers will be chosen by the individual universities and colleges. Inquiries and applications should be addressed to the directors of the programs in the following list. Early inquiry is advised, for many teachers will be appointed in the latter part of March.

Biology, chemistry, mathematics, and physics, for high-school teachers: A. B. Weaver, Department of Physics, University of Arizona, Tucson.

Engineering and physics, for high-school teachers: Earl R. Parker, Institute of Engineering Research, University of California, Berkeley.

Marine biology, for high-school and college teachers: Joel W. Hedgpeth, Pacific Marine Station, Dillon Beach, Calif.

Chemistry, for teachers in junior colleges: C. Freeman Allen, Department of Chemistry, Pomona College, Claremont, Calif.

Biochemistry, for high-school teachers: Robert H. Maybury, Department of Chemistry, University of Redlands, Redlands, Calif.

Chemistry and physics, for high-school and college teachers: Norman Kharasch, Department of Chemistry, University of Southern California, Los Angeles.

Chemistry and physics, for high-school and college teachers: Bert M. Tolbert, Department of Chemistry, University of Colorado, Boulder.

Astronomy, for college teachers: Donald E. Billings, High Altitude Observatory, University of Colorado, Boulder.

Biology, chemistry, mathematics, and physics, for high-school and junior college teachers: Merle G. Payne, Department of Chemistry, Colorado State University, Fort Collins.

Chemistry and physics, for high-school and college teachers: Clarence M. Knudson, College of Engineering, University of Denver, Denver, Colo.

Biology, chemistry, and physics, for high-school teachers: J. C. Kakavas, School of Graduate Studies, University of Delaware, Newark.

Biology, chemistry, and physics, for high-school teachers: Lloyd N. Ferguson, Department of Chemistry, Howard University, Washington, D.C.

Biology, chemistry, geology, psychology, meteorology, and physics, for high-school and college teachers: Leland

Shanor, Department of Biological Sciences, Florida State University, Tallahassee.

Microbiology, for high-school teachers: Leslie R. Hedrick, Department of Biology, Illinois Institute of Technology, Chicago.

Biology, chemistry, mathematics, and physics, for high-school and college teachers: Paul Klinge, Coordinator for School Science, Indiana University, Bloomington.

Radiation chemistry, for high-school and college teachers: Milton Burton, Radiation Project, University of Notre Dame, Notre Dame, Ind.

Biochemistry, for high-school teachers: Leland P. Johnson, Department of Biology, Drake University, Des Moines, Iowa.

Chemistry, for college teachers: Ralph L. Shriner, Department of Chemistry, State University of Iowa, Iowa City.

Botany, chemistry, and zoology, for high-school and college teachers: John A. Greenlee, Division of Science, Iowa State College, Ames.

Chemistry, for high-school and junior college teachers: J. W. Kercheval, Science Department, Iowa State Teachers College, Cedar Falls.

Chemistry, for high-school teachers: Ray Q. Brewster, Department of Chemistry, University of Kansas, Lawrence.

Chemistry and physics, for high-school and college teachers: Thomas D. O'Brien, Director of Academic Research, Kansas State College, Manhattan.

Biology, for high-school teachers: Otto M. Smith, Director of Science Institutes, Kansas State Teachers College, Emporia.

Biology, chemistry, geology, and physics, for high-school and college teachers: John F. Christman, Department of Biochemistry, Louisiana State University, Baton Rouge.

Physics, for high-school teachers: Howard Laster, Department of Physics, University of Maryland, College Park, Maryland.

Chemistry, for high-school teachers: Lowell V. Coulter, Department of Chemistry, Boston University, Boston, Mass.

Reactor physics, for college teachers: M. L. Wiedenbeck, Department of Physics, University of Michigan, Ann Arbor.

Experimental psychology, for college teachers: W. J. McKeachie, Department of Psychology, University of Michigan, Ann Arbor.

Chemistry, for high-school and college teachers: Richard B. Hahn, Department of Chemistry, Wayne State University, Detroit, Mich.

Physics, for high-school teachers: Arthur G. Rouse, Department of Physics, Saint Louis University, St. Louis, Mo.

Chemistry and physics, for high-school teachers: James A. Bradley, Department of Chemical Engineering, Newark College of Engineering, Newark, N.J.

Engineering, for high-school teachers: Richard C. Dove, Mechanical Engineering Department, University of New Mexico, Albuquerque.

Chemistry, mathematics, and physics, for high-school teachers: Burrell L. Wood, Department of Chemistry, New Mexico Institute of Mining, Socorro.

Chemistry, for high-school teachers: Howard Tieckelmann, Department of Chemistry, University of Buffalo, Buffalo, N.Y.

Chemistry and physics, for high-school teachers: F. Gordon Lindsey, Director of Summer Programs, Clarkson College of Technology, Potsdam, N.Y.

Biology, chemistry, and agricultural science, for high-school and college teachers: Philip G. Johnson, College of Education, Cornell University, Ithaca, N.Y.

Chemistry, for high-school and college teachers: Robert L. Strong, Department of Chemistry, Rensselaer Polytechnic Institute, Troy, N.Y.

Astronomy, biology, chemistry, physics, and psychology, for high-school and college teachers: W. A. Fullagar, dean, College of Education, University of Rochester, Rochester, N.Y.

Biological sciences, for high-school teachers: Daniel M. Lilly, Department of Biology, St. John's University, Jamaica, N.Y.

Biology, for college teachers: Thelma Howell, Biology Department, Wesleyan College, Macon, Ga.; (program to be conducted at Highlands Biological Station, Highlands, N.C.).

Biology, chemistry, statistics, and physics, for high-school and college teachers: Homer C. Folks, Department of Agronomy, North Carolina State College, Raleigh.

Biochemistry, for high-school teachers: Francis A. Jacobs, School of Medicine, University of North Dakota, Grand Forks.

Chemistry, physics, and other sciences, for high-school and college teachers: Horace H. Bliss, Oklahoma Science Service, University of Oklahoma, Norman.

Biology, chemistry, and engineering, for high-school and college teachers: Robert MacVicar, Graduate School, Oklahoma State University, Stillwater, Oklahoma.

Numerical analysis, for high-school and college teachers: A. T. Lonseth, Department of Mathematics, Oregon State College, Corvallis.

Chemistry, chemical engineering and physics, for college teachers: W. C. Fernelius, Department of Chemistry, Pennsylvania State University, University Park.

Biology and chemistry, for high-school teachers: John A. Southern, Department of Chemistry, Furman University, Greenville, S.C.

Biology, chemistry, and physics, for high-school and college teachers: H. W. Davis, Department of Chemistry, University of South Carolina, Columbia.

Botany, chemistry, geology, physics, and psychology, for high-school and college teachers: George P. Scott, Department of Chemistry, State University of South Dakota, Vermillion.

Chemistry, for high-school and college teachers: Robert L. Fischer, Division of Chemistry, Medical Units, University of Tennessee, Memphis.

Biology, chemistry, mathematics, and physics, for high-school and college teachers: Addison E. Lee, Department of Botany, University of Texas, Austin.

Biochemistry, chemistry, geology, and physics, for high-school teachers: K. LeRoi Nelson, Department of Chemistry, Brigham Young University, Provo, Utah.

Chemistry, for college teachers: W. J. Burke, Department of Chemistry, University of Utah, Salt Lake City.

Radiation physics, for college teachers: Earl L. Core, Department of Biology, West Virginia University, Morgantown.

Chemistry, chemical engineering, and microbiochemistry, for college teachers: Roy P. Whitney, Institute of Paper Chemistry, Appleton, Wis.

Biology, chemistry, and other sciences, for high-school teachers: Donald M. Bucklin, Department of Zoology, University of Wisconsin, Madison.

Early Tetrapod Life

The first tetrapods arose in the Devonian period. The evidence indicates that this was a time when the land areas in which the tetrapods evolved were subject to seasonal droughts or periods of aridity. A. S. Romer has suggested on various occasions that tetrapod limbs did not develop as an adaptation to terrestrial life itself, but, rather, as an adaptation which would assist an aquatic animal living under drought conditions to shift from drying pools to those that were less fleeting.

In a recent paper, Romer [*Evolution* **12**, 365 (Sept., 1958)] emphasizes that there were two distinct chapters in tetrapod history: (i) development of limbs giving potentiality of terrestrial existence, and (ii) utilization of these limbs for life upon the land. These two events need not have occurred synchronously; in fact, Romer believes that they were separated in time by many millions of years.

The development of limbs took place during the Devonian period, when the climate and lack of available food supply on land did not favor terrestrial vertebrate life. The beginning of actual life on land did not occur until the Upper Carboniferous period, very probably during late Pennsylvanian time, when the world climate and the evolution of insects made available the supply of animal food necessary for the existence of terrestrial vertebrates.—W. L. S., JR.

AEC Technical Films

The Atomic Energy Commission has announced that the 45 technical-level, professional motion pictures first screened last September in Geneva at the Second International Conference on the Peaceful Uses of Atomic Energy are available for loan and sale. The 16mm films, most of which are in color, cover major nuclear applications and research activities.

The Geneva films, in general too technical for lay audiences or secondary-school students, bring the total of professional-level, technical films available at the commission's Washington film library to 71 titles, and at 10 field libraries to 63 titles. The Washington and field libraries also have about 70 other less technical films appropriate and available for loan to junior and senior high schools, service and fraternal organizations, industry, and other private and governmental audiences of laymen.

Inquiries for information on loan and sale of the Geneva films to foreign users may be directed to the Public Information Service, U.S. Atomic Energy Commission, Washington 25, D.C. All films are now available in English for sale to foreign applicants and shortly will be available for sale in French, Spanish, or Russian. An overseas loan program is being arranged through the United States Information Agency and its overseas posts, and also through the commission offices in London, Brussels, Paris, Tokyo, and Buenos Aires.

U.K. Atomic Information

In order to make atomic information more easily available, the United Kingdom Atomic Energy Authority has decided to make fuller use of microphotography. The effect of this will be to make all nonsecret reports that have been prepared since 1947 readily obtainable. Complete sets are also being presented to a number of other countries and to certain international agencies. In addition to this, the Authority is increasing its facilities for supplying reports in conventional form as they are prepared. Details of the new methods follow.

Effective 16 February, a large number of unclassified and declassified reports, which have hitherto been obtainable only on loan from AEA libraries, will be available in micro form. These may be purchased from Micro Methods Ltd., of East Ardsley, Wakefield, Yorks, England. Micro Methods will provide a list of available reports on requset.

In addition, paper copies of all currently issued unclassified AEA reports may now be obtained against a running account from the Library, Atomic Energy Research Establishment, Harwell, Didcot, Berks. Subscribers may order all reports issued or those in any of 19 categories, such as biology and medicine, geology and mineralogy, instruments, and so forth.

Robot Seismographic Station

The United States has successfully operated a robot seismographic station that could prove useful in policing an international atomic test ban, the Commerce Department has disclosed.

The station, near Tucson, Ariz., automatically records earth tremors and transmits the information by radio to the Coast and Geodetic Survey's Tucson magnetic observatory, 15 miles away.

The Commerce Department described the station as "among the most sensitive in the United States." It said that "it has detected many earthquakes that would otherwise have been missed."

The successful development of an unmanned seismographic station illustrates one possible method for restoring the dependability of a proposed inspection system for monitoring an atomic test ban, particularly in the detecting and identifying of underground explosions, Commerce Department officials believe.

College Enrollment

Opening fall enrollment of degree-credit students (full-time and part-time) in the fall of 1958 registered its seventh consecutive annual rise, reaching an all-time peak. The total degree-credit enrollment in the fall of 1958 came to 3,258,556—a rise of 190,139, or 6.2 percent, above the figure for the fall of 1957. First-time degree-credit students increased to 781,075—a rise of 51,350, or 7.0 percent. These figures are from the U.S. Office of Education's circular on the 13th annual survey of opening (fall) enrollment in institutions of higher education.

The data for the publication were collected, verified, and compiled in 6 weeks from the time the questionnaire was originally mailed. Usable responses were received from 1897 of the 1903 institutions addressed, a response rate of 99.7 percent.

Role of Director of Defense Research and Engineering

In a directive instrumenting an aspect of the Department of Defense Reorganization Act of 1958, Neil McElroy, Secretary of Defense, has defined the role of the Director of Defense Research and Engineering. This position, now filled by Herbert York, supersedes the old position of Assistant Secretary for Defense (Research and Engineering).

Under the new regulation, the director will supervise all research and engineering activities in the Department of Defense. This would include such major units as the Advanced Research Projects Agency and the Weapons Systems Evaluation Group. The director will have explicit authority to "approve, modify or disapprove programs and projects of the military departments and other Department of Defense agencies." In addition, the director will serve as the principal adviser and staff assistant to the Secretary of Defense in the following fields: scientific and technical matters; basic and applied research; research, development, test and evaluation of weapons, weapons systems, and defense material; and design and engineering for suitability, productibility, reliability, maintainability, and materials conservation.

News Briefs

Last month Britain signed an agreement with the six-nation European Atomic Energy Community for cooperation in the peaceful uses of atomic energy. In signing for Britain, Selwyn Lloyd, the Foreign Secretary, said the pact provided a comprehensive framework through which practical cooperation could take place not only between Britain and the community but also between institutions and industrial concerns in the two areas. The 10-year agreement provides for the exchange of unclassified information between Britain's Atomic Energy Authority and the European Community's Commission.

* * *

Three Soviet scientists arrived in Washington on 11 February to start a 30-day survey of U.S. research developments in physiology and pharmacology of the nervous system. Late in 1958, an American neurological mission of six scientists went to the U.S.S.R. to make a similar study and will confer with the Soviet delegation during their stay in this country.

The members of the Soviet group are Sergey Viktorovich Anichov, professor, head of the department of pharmacology, Sanitary-Hygiene Medical Institute at Leningrad, and spokesman for pharmacology achievements in the U.S.S.R.;

Vladimir Sergeyevich Rusinov, head, department of physiology and pathology of the nervous system, Institute of Neurosurgery of the U.S.S.R. Academy of Medical Sciences; and Vasiliy Vasil'yevich Zakusov, director of the Institute of Pharmacology and Chemotherapy of the U.S.S.R. Academy of Medical Sciences.

* * *

Federal funds totaling $6 million were allocated in February by U.S. Commissioner of Education Lawrence G. Derthick to 1227 colleges and universities in all 49 states, the District of Columbia, Hawaii, and Puerto Rico for the establishment of National Defense Student Loan Programs. With the allocation of these funds, the total amount thus far appropriated for student loans, all nine basic programs authorized by the National Defense Education Act are now in operation.The act was signed by President Eisenhower last September.

* * *

The British Museum passed its 200th anniversary on 15 January. There was no celebration, and the museum staff carried on as usual, cataloging its daily inflow of 1500 publications to be added to the library's some 6 million books.

* * *

A "Report to the Nation" summarizing the progress made during the past 10 years against heart and blood vessel diseases was delivered in Washington on 19 February by the American Heart Association and the National Heart Institute. The report took the form of a review of advances in the cardiovascular field by six eminent physicians and scientists: Howard B. Sprague, Boston; Paul Dudley White, Boston; Irvine H. Page, Cleveland; Robert W. Wilkins, Boston; Michael E. DeBakey, Houston; and Robert W. Berliner, Bethesda, Md.

* * *

The fourth annual Thomas Alva Edison Foundation Awards for Children's Books included the following in science: *Science in Your Own Back Yard,* by Elizabeth K. Cooper (Harcourt Brace & Co.), as the best children's science book; and *Elements of the Universe,* by Glenn T. Seaborg and Evans G. Valens (E. P. Dutton & Co.), as the best science book for youth. Each winning author received a prize of $250 and the winning publishers received an Edison scroll.

* * *

The British Atomic Energy Authority plans to build a research station exclusively devoted to the study of thermonuclear power. It will probably be situated near the central atomic research station at Harwell, 50 miles west of London. The original intention was to carry out advanced thermonuclear studies in Winfrith, a deserted rural area 125 miles southwest of London where atomic power specialists already are investigating high-temperature, uranium-burning reactors. Apparently this plan has been abandoned. It is reported that atomic scientists are unwilling to work at Winfrith.

* * *

The track of Russia's Sputnik II, or Earth Satellite 1957 Beta, between 1 April 1958 and 14 April 1958, the day of its disintegration, is traced in an Air Force report just released through the Office of Technical Services, U.S. Department of Commerce.

* * *

A total of 142 secondary schools, both public and private, in the 49 states are offering courses in the Russian language to about 2400 students, according to a recent survey. There are more than 28,000 secondary schools in the nation, enrolling over 8 million students. The study was made by the National Information Center on the Status of Russian in United States Secondary Schools, located at Brooklyn College. The center was established last May as a result of a conference sponsored by the Modern Language Association of America.

* * *

The Indian Institute of Science, Bangalore, India, is celebrating its Golden Jubilee in 1959. The President of India opened the anniversary year at an inaugural function in February. The institute, the first of its kind to be established in India, has been a pioneer in advanced instruction and research in pure as well as applied sciences.

Grants, Fellowships, and Awards

Bio-sciences. The Sloan-Kettering Division of Cornell University Graduate School of Medical Sciences, New York, has announced a limited number of new special fellowships for study toward the Ph.D. degree in biology, biochemistry, or biophysics. These fellowships are primarily intended for recent baccalaureates, although candidates with some graduate training may also apply. The program is designed to develop scientists of unusual promise for original investigative work in the above fields. Students will have special opportunity to become acquainted with varied phases of the broad research program of the Sloan-Kettering Institute. Each fellowship includes full tuition and fees and a stipend of $3000 per annum. For details, write to the Office of the Director, Sloan-Kettering Division, Cornell University Graduate School of Medical Sciences, 410 E. 68th St., New York 21, N.Y.

NATO postdoctoral. The Department of State and the National Science Foundation have announced that the foundation has agreed to administer the selection of United States recipients of fellowships in a program recently established by the North Atlantic Treaty Organization. The new NATO program will provide post-doctoral fellowships in science for citizens of the NATO countries. The awards are designed to encourage further study in the sciences abroad. For this year, 20 fellowships will be given to United States citizens.

Awards will be made in the mathematical, physical, and engineering sciences, medical and biological sciences, including anthropology and psychology (excluding clinical psychology); and in selected social science fields. Included, as well, are interdisciplinary fields which overlap two or more scientific disciplines.

In view of the sponsorship and objective of the program, recipients are expected, in nearly all cases, to study abroad in a country that is a member of the NATO community. However, awards are not entirely restricted to study in a NATO country, and consideration will be given to those planning study elsewhere.

Evaluation and selection of candidates will be solely on the basis of ability. Applications will be evaluated for the National Science Foundation by panels of scientists appointed by and meeting under the auspices of the National Academy of Sciences–National Research Council.

Stipends for NATO fellowships will be $4500 for the full year and $3375 for the academic year. Limited round-trip travel and dependency allowances will be provided.

Applications and detailed information may be obtained from the Fellowship Office, National Academy of Sciences–National Research Council, 2101 Constitution Ave., N.W., Washington 25, D.C. Fellowship applications must be received by the NAS–NRC *by 30 March.* Awards will be announced on 12 May.

Social work. Students attending any approved graduate professional school of social work that offers a medical social field work placement are eligible for scholarships provided by the National Foundation. The student must be accepted for admission by a school accredited by the Council on Social Work Education but may file application for a scholarship pending acceptance for admission to the school. Deadline for filing applications is *1 April.* The student must have the intention of including the medical social field work placement in his educational program and of completing his study for the master's degree. Scholarships are ordinarily offered for the final year of the graduate program, but a few scholarships are awarded to well-qualified students for both years.

Applicants must be citizens of the United States or have filed a petition for naturalization. The age limit is 38.

Scholarships awards are based on the

needs of students and will ordinarily include assistance for maintenance and for tuition. No allowance for fees will be made. Selection of successful applicants will be made by a scholarship committee composed of appointed members of the National Association of Social Workers, Medical Social Work Section.

A new scholarship program for students entering the junior year of college and planning to prepare for medical social work has also just been announced. For information about this program, students should consult the dean of the college or university they are attending. For further information on either program, write: The National Foundation, Department of Professional Education, 800 2nd Ave., New York 17, N.Y.

Scientists in the News

WILLARD F. LIBBY, commissioner on the five-member Atomic Energy Commission, recently submitted his letter of resignation to President Eisenhower. Libby, the only scientist on the commission, will have completed 3 years of his term by 30 June. Before being appointed to a full term on the commission, he served 2 years to complete the unexpired term of physicist Henry deWolf Smyth.

Libby has indicated that he intends to return to teaching. Formerly, he was at the University of Chicago's Institute for Nuclear Studies and taught in the university's chemistry department. Libby, who is opposed to the cessation of nuclear tests, has been a spokesman for the AEC in the controversy over weapon testing.

The Wagner Free Institute of Science, Philadelphia, has scheduled a lecture series under its Westbrook Free Lectureship on the general topic "Evolution: from the Cosmos to Man." The following scientists will participate: 2 April, HARLOW SHAPLEY, "The evolution of the material universe"; 9 April, CONWAY ZIRKLE, "How plants and animals evolve"; 16 April, WILLIAM L. STRAUS, JR., "The evolution of man." This series was begun in 1912 and provides three lectures each year by prominent scientists. The original endowment was established by Richard B. Westbrook.

ABRAHAM STONE, director of the Margaret Sanger Research Bureau, New York, left in early February on a trip around the world in connection with the problems of population and family planning.

PAUL W. McDANIEL, deputy director of the Division of Research of the Atomic Energy Commission, has been chosen by the National Civil Service League as one of the ten top career men in the Federal Government for 1959. The league is a nonpartisan organization of "citizens for better government through better personnel." McDaniel was selected to receive one of the league's fifth annual Career Service awards because of his compefence, efficiency, character, and continuity of service.

HUBERTUS STRUGHOLD, professor of space medicine at the Air Force School of Aviation Medicine, Randolph Air Force Base, Tex., has been named the 1958 winner of the Dr. John J. Jeffries Award of the Institute of the Aeronautical Sciences for his outstanding contributions in space and aviation medicine research. Often called "the father of space medicine," Strughold was the first scientist to define specific areas to be investigated in space medicine and the first to give a comprehensive definition of space and space equivalency, Further, he was the first chief of the School of Aviation Medicine's department (now division) of space medicine. The award was presented at a dinner on 26 January at the Astor Hotel, New York.

MARTIN LINDAUER of the University of Munich, Germany, has been appointed Prather lecturer in biology for 1958–59 at Harvard University. He will present a series of lectures on the evolution of social communication among bees, 9–21 April.

STUART S. STEVENSON, acting chairman of the department of pediatrics at the University of Pittsburgh School of Medicine, has been appointed professor and chairman in the department of pediatrics at Seton Hall College of Medicine.

E. WILLARD BERRY, professor of geology at Duke University, has left for Australia, where he will conduct a study of coals from April until July. He will return to this country early in September.

Queen Elizabeth named the following scientists and others associated with scientific work in the New Year Honours list:

Baronet: KENNETH W. M. PICKTHORN, during 1935–50 member of Parliament for the University of Cambridge, for political and public services.

Companion of Honour: Sir JOHN BEAZLEY, emeritus professor of classical archeology, University of Oxford, for services to scholarship.

Knights: ALEXANDER W. G. EWING, director of the department of education of the deaf, University of Manchester; STUART GILLETT, until recently chairman of the Tanganyika Agricultural Corporation; HENRY R. F. HARROD, university lecturer in economics, University of Oxford; REGINALD P. LINSTEAD, rector of the Imperial College of Science and Technology, University of London; DOUGLAS W. LOGAN, principal of the University of London; KELVIN T. SPENCER, chief scientist, Ministry of Power; ARTHUR P. THOMSON, professor of therapeutics and dean of the Medical School, University of Birmingham.

Knight Commander in the Order of the British Empire: ALBERT E. AXON, chancellor of the University of Queensland, for public services; GEORGE W. H. GARDNER, director of the Royal Aircraft Establishment, Farnborough; MARCUS L. E. OLIPHANT, director of the School of Research in Physical Sciences, National University, Canberra, Australia; GEOFFREY S. PEREN, principal of Massey Agricultural College, New Zealand; Sir GEORGE WILSON, chairman of governors, West of Scotland Agricultural College.

Companion of the Bath: Air Commodore R. H. E. EMSON, director of air armament research and development, Ministry of Supply; W. B. LITTLER, director-general (scientific research, munitions), Ministry of Supply; J. W. STORK, director of studies, Britannia Royal Naval College, Dartmouth; A. A. PART, under-secretary, Ministry of Education.

Companion of St. Michael and St. George: T. H. SEARLS, until recently director, Universities and Adult Education Department, British Council; H. C. WEBSTER, professor of physics, University of Queensland, for services to the Federal Government of Australia.

Commander in the Order of the British Empire: MURIEL E. BELL (Mrs. Hefford), nutritionist to the Department of Health and supervisor of Nutrition Research Department, Medical Research Council, New Zealand; M. M. BURNS, director of Canterbury Agricultural College, Christchurch, New Zealand; W. A. S. BUTEMENT, chief scientist, Department of Supply, Australia; M. COOK, chairman of the metals division, Imperial Chemical Industries, Ltd.; I. J. CUNNINGHAM, superintendent of the Animal Research Station, Wallaceville, New Zealand; I. DE BURGH DALY, until recently director of the Institute of Animal Physiology, Babraham, Cambridge; Capt. N. FAWCETT, H.M. chief inspector of explosives, Home Office; P. T. FLETCHER, deputy managing director, Industrial Headquarters, Atomic Energy Authority, Risley; T. A. LANG, associate commissioner, Snowy Mountains Hydro-Electric Authority, Australia; A. B. LILLEY, medical director of the Cancer Council, New South Wales; S. C. LONGHURST,

until recently a member of the Forestry Commission; R. A. LOVELL, chief mechanical engineer, Ministry of Transport and Civil Aviation; W. T. J. MORGAN, professor of biochemistry, University of London, and member of the Biological Research Advisory Board, Ministry of Supply; H. J. PLENDERLEITH, keeper in the British Museum; E. E. POCHIN, director of the department of clinical research, University College Hospital Medical School; J. A. RATCLIFFE, chairman of the Radar and Signals Advisory Board, Ministry of Supply Scientific Advisory Council, and reader in physics, University of Cambridge; R. H. SCHLOTEL, director of engine research and development, Ministry of Supply; R. B. TENNENT, director of agriculture, New Zealand; H. W. THOMPSON, lecturer in chemistry, University of Oxford, senior regional scientific adviser for civil defense, Southern Region; S. J. WATSON, professor of agriculture and rural economy, University of Edinburgh.

FRANCIS H. C. CRICK, molecular biologist of Cambridge University, England, is visiting professor of chemistry at Harvard University for the spring term. He is conducting a course on the chemistry and biology of biological macromolecules. Crick is coauthor, with James D. Watson, associate professor at Harvard, of the Watson-Crick model for the structure of deoxyribonucleic acid (DNA).

KATHARINE DODD and MARIAN W. ROPES received the New York Infirmary's annual Elizabeth Blackwell Awards for distinguished contributions to medicine at a ceremony on 26 January. Dr. Dodd, professor of pediatrics at the University of Louisville's School of Medicine, was cited for achievements as a physician, investigator, and teacher. Dr. Ropes, assistant clinical professor at the Harvard Medical School, was cited for research and teaching in internal medicine.

Lt. Gen. RAYMOND A. WHEELER, past-president and director of the Society of American Military Engineers, received the Hoover Medal for 1958 on 19 February during a special meeting and dinner in Washington, D.C. This engineering award was founded by the American Society of Civil Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers.

LOUIS MARS, psychiatrist and Minister of Foreign Affairs of Haiti, has been named director of the new Haiti Psychiatric Institute, Port-au-Prince, where treatment of the mentally ill will be based primarily on drug therapy. The institute is being financed by the Haitian Government and three pharmaceutical companies, the Schering Corporation, Bloomfield, N.J.; Hoffman–La Roche, Inc., Nutley, N.J.; and Wyeth International, Radnor, Pa. Work will be carried out under the auspices of MEDICO (Medical International Corporation), the Government of Haiti, and the Department of Mental Hygiene of the state of New York. NATHAN S. KLINE, director of research at Rockland State Hospital, Orangeburg, N.Y., will serve as consultant to the institute.

ROY H. COOK, chairman of the departments of mathematics and physics at Pratt Institute's School of Engineering, has been appointed dean of the school.

LAWRENCE S. DILLON, associate professor of biology at the Agricultural and Mechanical College of Texas, left on 3 February for the University of Queensland, Brisbane, Australia, where he will conduct research on the evolution of the vertebrates, under a science faculty fellowship from the National Science Foundation.

The National Aeronautics and Space Administration has announced the appointment of the following chairmen for its 13 new research advisory committees: fluid mechanics, WILLIAM R. SEARS, head of the Graduate School of Aeronautical Engineering, Cornell University; aircraft aerodynamics, R. RICHARD HEPPE, manager of advanced aerodynamics research, California Division of Lockheed Aircraft Corporation; missile and spacecraft aerodynamics, H. GUYFORD STEVER, associate dean of engineering, Massachusetts Institute of Technology; control, guidance, and navigation, LOUIS N. RIDENOUR, assistant general manager of research and development, Missile Systems Division of Lockheed Aircraft Corporation; chemical energy processes, JAMES A. REID, executive vice president and general manager of Astrodyne, Inc.; nuclear energy processes, WALTER H. JORDON, assistant director of the Oak Ridge National Laboratory, Union Carbide Nuclear Company; mechanical power plant systems, GORDON BANERIAN, manager of the Turbo-Machinery Division, Aerojet-General Corporation; electrical power plant systems, KRAFFT A. EHRICKE, assistant to the technical director of Convair-Astronautics, a division of General Dynamics Corporation; structural loads, E. Z. GRAY, systems engineering director of Boeing Airplane Company; structural design, E. E. SECHLER, professor of aeronautics, California Institute of Technology; structural dynamics, MARTIN GOLAND, director of Southwest Research Institute; materials, R. H. THIELEMANN, senior metallurgist, Stanford Research Institute; aircraft operating problems, WILLIAM LITTLEWOOD, vice president of equipment research, American Airlines, Inc.

Recent Deaths

VAGHARSHAG BOGHOSIAN, New York, N.Y.; 62; dermatologist and syphilologist in charge at Goldwater Memorial Hospital, and associate professor of dermatology at New York University Medical School; 25 Jan.

WILLIAM L. BURLISON, Urbana, Ill.; 76; head of the agronomy department at the University of Illinois from 1920 until his retirement in 1951; pioneered in the development of the soybean, now the second most important crop in Illinois; 25 Dec.

SAMUEL W. EDGECOMBE, Beirut, Lebanon; 51; dean of the Faculty of Agricultural Sciences and professor of horticulture at the American University of Beirut, Lebanon, since 1952; professor and head of the department of horticulture of Utah State Agricultural College, 1947–52; vice president and director of research of the W. Atlee Burpee Company, Philadelphia, Pa., 1944–47; 5 Feb.

ARTHUR O. FRIEL, Concord, N.H.; 73; reporter and explorer who went to South America in 1922 and established the existence of "white Indians" on the Rio Ventuari in Venezuela; 28 Jan.

SAMUEL JOSEPH, New Rochelle, N.Y.; 77; founded the department of sociology at City College, New York, in 1941 and was its chairman until 1947; head of the college's social research laboratory from 1929 to 1947; 9 Feb.

ALFRED KOHN, Prague, Czechoslovakia; 91; professor emeritus of histology, German University, Prague; known for his work on the paraganglia, chromaffine system, parathyroids, and the origin of Schwann cells; 15 Jan.

MICHAEL M. LIWSCHITZ-GARIK, New York, N.Y.; 75; professor of electrical engineering at Brooklyn Polytechnic Institute since 1940; 8 Feb.

LEO J. O'DONNELL, New York; 58; former director of obstetrics and gynecology at Lenox Hill Hospital, which he joined in 1927; former associate clinical professor of obstetrics and gynecology at New York University; 31 Jan.

WILLIAM D. SHERWOOD, New York; 76; retired neuropsychiatrist; former professor of neurology at the College of Physicians and Surgeons of Columbia University, and professor of clinical neurology and psychiatry at the New York Postgraduate Medical School; 1 Feb.

ALBERT VANDER VEER, Charlotte, N.C.; 79; specialist in allergies and author of many articles; 31 Jan.

Book Reviews

Project Sherwood. The U.S. program in controlled fusion. Amasa Bishop. 228 pp. $5.75. **The Transuranium Elements.** Glenn T. Seaborg. 354 pp. $7. **U.S. Research Reactor Operation and Use.** Joel W. Chastain, Jr., Ed. 384 pp. $7.50. **Radiation Biology and Medicine.** Selected reviews in the life sciences. Walter D. Claus, Ed. 968 pp. $11.50. **Uranium Ore Processing.** J. W. Clegg and D. D. Foley, Eds. 450 pp. $7.50. **Thorium Production Technology.** F. L. Cuthbert. 320 pp. $6.50. **Physical Metallurgy of Uranium.** A. N. Holden. 272 pp. $5.75. **Physical Metallurgy of Uranium.** A. N. Holden. 272 pp. $5.75. **Solid Fuel Reactors.** J. R. Dietrich and W. H. Zinn. 864 pp. $10.75. **Boiling Water Reactors.** Andrew W. Kramer. 592 pp. $8.50. **Fluid Fuel Reactors.** J. A. Lane, H. G. MacPherson, Frank Maslan. 1008 pp. $11.50. **Sodium Graphite Reactors.** Chauncey Starr and R. W. Dickinson. 304 pp. $6.50. **The Shippingport Pressurized Water Reactor.** Personnel, Naval Reactor Branch, Division of Reactor Development, U.S. Atomic Energy Commission, Westinghouse Electric Corp., Bettis Plant, and Duquesne Light Company. 600 pp. $9.50. Addison-Wesley, Reading, Mass., 1958.

The simultaneous appearance of these twelve volumes, replete with up-to-date information on peacetime nuclear energy development in the United States, calls for a brief explanation. They make up the "presentation set" given by the United States to each of the hundreds of official delegates of the countries represented at the second Geneva Conference on the Peaceful Uses of Atomic Energy, held in September 1958. Written under contract with the Atomic Energy Commission, by many scientists, their purpose was to present a picture of the progress in nuclear energy in the United States in the three years since the first Geneva conference.

There is no doubt that the express purpose of the series was amply fulfilled at Geneva, for these are attractive, well-produced volumes containing an impressive amount of material. In addition to having been distributed at Geneva, however, they are now being sold through normal channels by the publisher and are pleasantly priced, a result of the specific publication arrangements between the AEC and Addison-Wesley. Being written under contract, and in most cases on a tight time schedule, the books might be expected to be hasty compilations of already existing material. However, most of the writing is of high quality, and the technical appearance of all the volumes, including the tables, drawings, and photographs, is excellent.

The nature of the volumes varies widely, from *Project Sherwood,* which is short and non-technical, to *Radiation Biology and Medicine,* with many long, highly technical papers. As a whole, the series represents almost a full coverage of the field of modern nuclear energy for peace in this country, the principal omission being the highly developed mathematical theory of nuclear reactors. In some phases, the series extends beyond the usual definition of the field of nucleonics as "the production of energy from the nucleus and the directly related parts of physics, chemistry, and the biological sciences." For example, the many fields in which tracers are used are thus not part of nucleonics proper, although many of these uses are covered in *Radiation Biology and Medicine.* However, this series of 12 volumes fits the field of nuclear energy rather well, for fully five volumes are devoted specifically to nuclear reactors. The others deal with matters connected directly with the production of nuclear energy, although in the chemistry and biological volumes a fair fraction of the material is further afield.

The short *Project Sherwood* is certainly not at all the result of a hasty compilation of existing reports. Written by one individual, it gives a clear description at the layman's level of the progress thus far in Project Sherwood, the code name of the United States effort to achieve the thermonuclear reaction. The well-written text and the remarkable drawings of "pinch effects," "Perhapsatrons," and "Stellerators" (produced by J. Banks of Addison Wesley) make the reading of this book a pleasure. Actually, the over-all picture of thermonuclear fusion is now much more discouraging than it was when overoptimistic reports were released in January 1958 by the United States and Great Britain. However, Bishop presents an optimistic view of the wide-ranging fusion activities now underway in the United States. The British and Soviet efforts in the field are unfortunately not described, but this is not a crippling omission, for at the second Geneva meeting it was abundantly clear that all three nations are pursuing closely similar approaches.

In *Transuranium Elements,* Seaborg describes the enormous effort of separating plutonium from reactor uranium during the war years, and the later accomplishments in the production of further elements up to the present limit at element 102 (added in the preface). Like the fusion volume, this book has only one author, is highly authoritative, and is carefully written. Actually, it is an extensive expansion of a lecture series given by Seaborg at Yale University. Although not meant to be a highly technical book, it nevertheless contains an enormous amount of information on the chemical, physical, and nuclear properties of the manmade elements. In addition, the actual events in the discovery of each new element have been carefully recreated, by the principal participant, and make stimulating reading indeed. A minor curious matter is the enormous number of names that are listed in the first third of the book, together with opening and closing apologies to those whose names were omitted. But perhaps this cataloging is simply a sign of the team nature of modern research, involving the cooperation of so many individuals to attain a desired goal.

More than the other volumes, *U.S. Research Reactor Operation and Use* bears the characteristics of being written somewhat hurriedly to order. Most of the book does not concern the operation and use of research reactors but is made up of their descriptions, together with many pictures of their various features. There is a short chapter on typical research performed with reactors but the material is much too descriptive and abbreviated to be useful to those engaged in research. The chapters on the operation of research reactors tend to be at the administrative level, with reproductions of organization charts and work schedule sheets. While the book is hardly a handbook for individuals operating research reactors or doing research with them, it would be a good introduction to the general types of research reactors that are available, the number of people required to run them, and their probable cost.

Radiation Biology and Medicine is a large, carefully edited volume containing a wealth of high-level material on the effects of radiation on living material. Although written by more than 50 authors, it is so well organized that there are no sharp discontinuities in treatment. A wide range of material is covered, from the basic mechanisms of radiation

interactions with cells to the widespread uses of tracers in many fields and the related problems of radiation safety. Very extensive lists of references, running at times to several hundred items, appear at the ends of the chapters.

The volumes *Uranium Ore Processing* and *Thorium Production Technology* are also edited collections of technical reports, written by many experts. Although the second is more heavily edited, they both are at a high technical level, well organized, and should be of great value to workers in the field of fuel production. The material in both is presented in somewhat condensed form, but the ample reference material, although primarily in the form of government reports, should serve as valuable supplements.

Physical Metallurgy of Uranium is not an edited collection of reports but more in the nature of a basic textbook, having been written by Holden during a period of several years. It gives a clear description of the basic properties of uranium, at a more elementary level than the three preceding volumes. Many recent data on the physical properties of uranium are presented, usually in the form of carefully prepared graphs. Included also are many beautiful photographs of various metallurgical features of uranium.

The last five volumes summarize the results of the nuclear power program in the United States over the past decade. Prepared by experts in the field and published with record speed, the volumes were made available by the U.S. Atomic Energy Commission to foreign delegates at the second Geneva Conference of September 1958. Together, they constituted a technical tour-de-force that could be matched by no other nation.

All of the power reactors under development in the United States are discussed in these volumes, including current favorites such as the boiling water reactor and the organic moderated reactor, which were relatively late starters in the race for economic nuclear power. One volume is devoted exclusively to Admiral Hyman Rickover's PWR, or pressurized water reactor, which is now in routine, high-power operation at Shippingport, Pennsylvania, and may eventually feed 100 megawatts of electricity into the grid of the Duquesne Light Company of Pittsburgh.

The volume *Boiling Water Reactors* gives a chronological account of their development from early concepts to the construction and operation of the EBWR at the Argonne National Laboratory. The design of the 180-megawatt Dresden Nuclear Power Station is also discussed, as is that of its 5-megawatt prototype reactor, the VBWR, built and operated by the General Electric Company's Vallecitos Atomic Laboratory at Pleasanton, California. The professional editor, A. W. Kramer, deserves credit for transforming a motley collection of scientific papers into a highly readable book. However, a considerable amount of gobbledegook remains, particularly in the discussions of the stability of boiling water reactors.

The collection of papers in *Solid Fuel Reactors* has also been improved by the capable work of its editors, J. R. Dietrich and W. H. Zinn. The most important reactor types discussed here are the fast breeder and the organic moderated reactor. The EBR reactors and the Enrico Fermi Atomic Power Plant are explained in considerable detail. Like the Dresden Station, the latter is in an advanced construction stage and involves a large financial investment by private industry. The chapter on organic moderated reactors includes a discussion of the properties of organic liquids under irradiation, a description of the OMR experiment at the National Reactor Testing Station in Idaho, and some studies of possible OMR power applications. Considerable space is allotted to recent paper studies of deuterium oxide power reactors and to gas-cooled reactors with either graphite or deuterium oxide as the moderator. The final chapter describes current research and development work carried out by the Hanford Laboratories on plutonium-enriched fuel elements.

The volume *Sodium Graphite Reactors,* edited by Chauncey Starr and R. W. Dickinson of Atomics International, contains a complete discussion of the sodium reactor experiment (SRE) at Santa Susanna, California. Like the OMRE of the preceding volume, the SRE was designed and is being operated for the AEC by Atomics International of Canoga Park, California. Some large-scale sodium graphite concepts are also described, including the Hallam (Nebraska) reactor currently under development. A chronological record of operations on the SRE (chapter 7-5) gives some indication of the difficulties encountered in bringing any novel reactor concept into sustained operation.

The final volume of the series, *Fluid Fuel Reactors,* discusses various approaches to this novel reactor type. The major concepts under development are the aqueous homogeneous reactor and the molten salt reactor at the Oak Ridge National Laboratory and the liquid metal fuel reactor at the Brookhaven National Laboratory. As noted by A. M. Weinberg in his foreword to the book, the solid fuel reactor is primarily a mechanical engineering device while the liquid reactor is a chemical plant. Which will win out is still a moot question. Technical feasibility has already been demonstrated for solid fuel reactors, but there are few who expect these reactors to compete in the near future against large, fossil fuel power plants in the United States. On the other hand, the technical feasibility of liquid fuel reactors still remains to be demonstrated.

The technical achievements of the United States in the nuclear power field are well represented by these five volumes. The feasibility of several reactor concepts has been established by progressing from small-scale experimentation through large-scale research and development and finally to one or more reactor experiments. A few medium power plants are actually in various stages of construction. It has been a slow and expensive process, but a great deal has been learned about the technology of such novel materials as hafnium-free zirconium, liquid sodium, organic liquids, and uranium solutions at high temperatures, and of the physical limitations and compatibility of reactor components in a strong radiation field.

The volumes also attempt a connected history of each reactor concept. However, the key efforts by many scientists and administrators have been dimmed by time, and a number of important contributions are no longer recalled. Again, what do not appear in these five volumes are the negative aspects of the United States' nuclear power program, the doldrums of the immediate postwar years, the continued struggle for support of the existing programs and the fact that we are lagging behind other nations in the planned construction of large-scale nuclear power plants. The lack of firm commitments between government and industry is seen in the recent withdrawal by industry from the PAR project, an aqueous homogeneous reactor discussed in the volume on fluid fuel reactors.

D. J. HUGHES
J. CHERNICK
Brookhaven National Laboratory

Physiological Bases of Psychiatry. Part 1, *From Pavlovian Laboratory.* Part 2, *From Behavior Laboratory.* W. Horsley Gantt, Ed. Thomas, Springfield, Ill., 1958. xiii + 344 pp. $10.50.

Part 1 of this monograph consists of 18 widely varying papers on various aspects of psychophysiology presented at the 25th anniversary of the establishment of the Pavlovian Laboratory, Johns Hopkins University. Part 2 consists of five papers on the same general subject presented later at the Behavior Laboratory, Cornell University. Part 3 is a list of publications from the Pavlovian Laboratory.

The two laboratories are the only ones in the United States in which the Pavlovian psychophysiological approaches to the study of normal and abnormal behavior are actively employed [see the recent review by G. Razran on "Soviet psychology and psychophysiology," *Sci-*

ence **128**, 1187 (1958), in which the scope of psychophysiology in Russia is emphasized]. The contributions in the present monograph show clearly how flexible and useful the conditional reflex method is when properly applied to the study of behavior. It is a true physiological method, one which requires a logical and skillful experimental approach. Perhaps this is why the method is not so popular among behaviorists who do not belong to the Pavlovian group.

Of particular interest are the studies of visceral responses and their role in altered behavior. The cardiac conditional reflex, for example, is readily established. But it is resistant to extinction, and an increased heart rate may persist for several years without reinforcement, representing an inertness to modification that is inappropriate to existing circumstances (schizokinesis).

The individual papers vary widely in subject and quality. Some read very clearly and smoothly—for example, the paper by Moore on "Conditioning and stress in the newborn lamb and kid." The clarity of this paper is accentuated by its freedom from the abbreviations that clutter up many of the other papers.

In spite of the diversity of the individual contributions and the rather haphazard organization, this is a valuable and most interesting monograph.

ERNEST GARDNER
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Wayne State University

Theory and Methods of Scaling. Warren S. Torgerson. Wiley, New York; Chapman and Hall, London, 1958. xiii + 460 pp. Illus. $9.50.

This book should be within arm's reach of all students, teachers, and researchers in the social sciences who are concerned with problems of measurement. It appears to cover all the important contributions to date in scaling theory and techniques. The skill and competence with which the author has organized the extensive contributions to scaling are indeed impressive.

Because of the clear perspective given by the book on the current status of scaling methodology, it is relatively easy to evaluate critically the developments to date. In fact, I would have liked a somewhat more critical evaluation in view of the great variety and diversity of methods. This was not, however, the primary task assigned the author by the committee under whose direction the book was prepared.

Perhaps it is a criticism of the mission assigned the author rather than of the book itself that it may tend to perpetuate the schism between testing and scaling theory, whereas there is mounting evidence that an integration of the two is not only feasible but highly desirable. Along the same line, those dedicated to the operational point of view may regard the rather extensive philosophical development of measurement concepts as a proliferation of semantic red herrings.

The construction of a fundamental framework within which one develops a presentation is necessarily somewhat arbitrary. The notions of *object, attribute,* and *magnitude* seem, however, most happily chosen and serve as a solid and well-anchored set of coordinates from which the more detailed framework proceeds. The utility of the additional concept of *quantity* as distinguished from *magnitude* is not so compelling, however, unless it was meant to include the concept of replication. The definition given seems to preclude this, and its function in the more detailed superstructure is not highlighted, even though it might be implied.

Although the mission of the book is essentially reportorial rather than critical in nature, two distinctly different fundamental points might appropriately have been emphasized. One of these is the vast amount of covariant information in the experimental data ignored by both the paired comparisons and successive intervals models. The other is the flagrant violation of one of the basic principles of scientific methodology—that is, the principle of parsimony, by the deterministic techniques.

In general, the material seems to be extremely well structured and well organized. However, I was surprised to find a discussion of the Horst and Guttman principal components models included in the chapter on deterministic models. These would seem to belong in the chapter on multidimensional techniques and are nothing if not probabilistic. Perhaps one of the reasons for this apparent displacement is that Guttman himself has failed either to recognize or to emphasize the true nature and importance of his contribution in the principal components approach.

A minor detail is the crediting of Horst with the least squares solution of the missing data problem for the paired comparison model rather than for the successive interval type model. Another detail which applies to all books dealing with multivariant analysis techniques concerns mathematical notation. The obvious notation for such techniques is that of matrix algebra. Although the book employs matrix notation in a few of the developments, it clings for the most part to the clumsy and untidy summation notation of scalar algebra. In this respect it merely follows an unfortunate tradition, and perhaps there is no particular reason why this book should have been the first to break with it.

The type and format are in the excellent tradition of the publisher. The only obvious improvement would have been to carry the chapter number along with the title at the head of each page. With so many back references, rapid referral to preceding relevant equations and passages would have been greatly facilitated by this device.

Although the lack of exercises and extensive numerical examples limits the usefulness of the book as a text on scaling theory and methods, its value as a ready reference for students, instructors, and researchers, striving toward greater precision in all the social sciences, cannot be overemphasized.

PAUL HORST
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Science and the Detection of Crime. C. R. M. Cuthbert. Philosophical Library, New York, 1958. 244 pp. Illus. $10.

As stated in the preface, the purpose of this book "is to provide the reader with an accurate and authoritative account of the work undertaken in the Forensic Science Laboratory at New Scotland Yard and to illustrate how a small group of scientific workers can render valuable service to the detective force in its constant war against crime. The work is not intended as a scientific text book, but it is hoped that, in addition to being of interest to the ordinary reader, it may be of some value to young detective officers and others whose work makes it necessary to know the extent to which science can assist in the investigation of crime."

On the whole, the book accomplishes the purpose for which it was designed. It is especially suitable for the lay reader who has a limited understanding of scientific crime investigation, and it will prove attractive to those who enjoy "whodunits." It is of more doubtful value to the professional policeman (unless he, too, enjoys "whodunits"), who should have a more thorough indoctrination into the facilities, operation, and investigative usefulness of a modern crime laboratory than is provided by this book.

Seven of the chapters deal with the work of laboratory specialists: the forensic pathologist, the serologist, the forensic chemist and biologist, the physicist, the toxicologist, the document examiner, and the ballistics expert, respectively. Six chapters deal with criminal specialties: stolen articles and fraud, fire and sabotage, breaking offenses, abortion, drug trafficking, and alcohol and motor accidents, respectively.

The chapters on the document examiner and the ballistics expert are not included in the group of chapters devoted to the laboratory specialists, perhaps because these two categories of specialists operate in fields that are not so clearly areas of "pure" or basic science. Instead, the two chapters devoted to the document examiner and the ballistics expert are inserted in the series devoted to criminal specialties, between the chapter on breaking offenses and that on abortion. The author has also illogically included a chapter on criminal responsibility between the chapter on drug trafficking and that on alcohol and motor accidents. It appears that the organization of the book could be improved by rearranging the chapter sequence.

The next-to-last chapter deals with instructive and unusual cases and adds materially to the "whodunit" value of the book. The introductory chapter contains an interesting account of the development of scientific crime investigation and the establishment of crime laboratories in England.

The concluding chapter—on some foreign laboratories—is not sufficiently detailed to give the criminalist an understanding of the facilities of these laboratories in terms of the quality and quantity of staff and equipment.

The author has illustrated his discussions of scientific techniques with examples drawn from actual criminal cases. It is these accounts which make the book appealing to the lay reader.

O. W. Wilson

School of Criminology, University of California

Introduction to Historical Geology. Raymond C. Moore. McGraw-Hill, New York, ed. 2, 1958. ix + 656 pp. Illus. $7.95.

Extensive expansion and revision mark this new edition of a widely used text by one of the world's grand masters of the historical geology chessboard. Except for some illustrations, little remains unchanged in the new work. The page size is larger, the text is longer, and the 600 illustrations nearly double the number in the earlier edition.

After first treating the scope of historical geology and evolution, the book examines briefly several theories of our earth's origin, without, however, supporting any specific hypothesis. Next comes a considerably expanded coverage of the Precambrian, here called the Cryptozoic eon. After this, individual chapters treat each succeeding geologic period, describing rocks and fossils, paleogeographic history, life, climate, and economic resources, all primarily from the viewpoint of a geologist working in North America. The final chapter outlines our scanty knowledge, as of several years ago, of man's geologic history. Recent finds—such as *Oreopithecus,* the Tuscan ape man, or the Swanscombe man—are not discussed, and the reading list needs some updating. For example, Wormington's classic work, *Ancient Man in North America,* is now in its fourth edition, not its second, and although one of Sellard's earlier papers is mentioned, his later book is not.

Three appendices complete the text. The first describes fossil organisms and is a superb exposition, reflecting the author's international eminence in paleontology. The second pictures many common lithologic symbols, and the last provides a glossary of technical terms.

Completely new features in this edition, deserving of special commendation, are the list of suggested readings and the dozen or so review questions at the end of each chapter. Each of the questions is carefully designed to induce the student to think and to reason from a background of factual information acquired through previous study.

Some terms not commonly used in the United States, but eminently satisfactory, are applied throughout the book. The European division of the Cenozoic into Paleogene and Neogene is adopted, and dolomitic rocks are called dolostones. Is the influence of a standard glossary at last infiltrating geologic science? The numerous illustrations, many of them new, are uniformly clear and appropriate. Some, such as the geologic maps showing outcrop and subsurface occurrences of the rocks of each system, provide useful reference information on every period since the Cambrian.

For teachers of historical geology this book is an excellent text. It provides a wealth of factual information, useful for stretching the minds of even the most competent students.

Hall Taylor

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Scientific Manpower in Europe. Edward McCrensky. Pergamon Press, New York and London, 1958. ix + 188 pp. $4.50.

"The role of management of scientists in government is the principal theme of this study." The first three chapters consider some of the things a scientist looks for in a government career, some of the methods used by several Western European governments to attract and hold scientists in public service, and the levels and systems of payment. The material is drawn from Great Britain, France, Western Germany, the Netherlands, and the Scandinavian countries.

Three other chapters describe (i) the representation of scientists in the establishment of employment conditions and rates of pay—for example, through the highly organized unions of the Scandinavian countries and the formal channels for joint consultation in Great Britain; (ii) the higher education of engineers in several countries; and (iii) several national patterns for the organization of research. A concluding chapter makes comparisons with the United States. These topics are treated very briefly.

There is growing recognition in the United States of the need for thorough and systematic review, and probably revision, of administrative practices controlling the recruitment, promotion, payment, and transfer of civil service scientists and engineers. This is all part of the larger issue of how best to organize and manage a government scientific program of expanding immensity. McCrensky's little book touches on many aspects of these problems, describes systems in use elsewhere, once in a while expresses a judgment as to how effectively different systems work, and thus provides ideas that might well be considered in the United States. But nothing is treated in depth; decisions to change present practices would require substantially more information than the author presents.

Dael Wolfle

American Association for the Advancement of Science

Principles of Research in Biology and Medicine. Dwight J. Ingle. Lippincott, Philadelphia, Pa., 1958. xv + 123 pp. $4.75.

In this unusual little book, which is addressed to "students who are preparing for or are beginning research in macrobiology and medicine," the author has attempted to survey the rationalities and methods of science all the way from basic aims and the fundamentals of logic to the selection and care of laboratory technicians. He makes this attempt in some 120 pages of short, concise assertions, aided by quotations from Lewis Carroll but without the aid of any illustrations, tables, quantitative data, or symbolic methods and with the introduction of very few examples.

The book is fundamentally sound but so condensed into generalities that controversial points are not explicitly asserted. It is hard to argue with the politician who asserts that evil is bad, and it is probably just as hard to deny, for example, that "causality is a useful assumption for scientists in the fields of

biology and medicine." If one feels uneasy about Ingle's "basic assumptions" that "if conditions are the same, the results will be the same," or that "when other factors are constant, each variable permits but one maximum," he may find consolation in the "self-evident assumption" that "some degree of uncertainty, however slight, remains in all phenomena, and natural laws are presently regarded as statistical."

This book is evidently the outgrowth of a great deal of reading and reflection. It might have been prepared by perusing treatises on research and attempting to condense the gist of each into a single sentence, with subsequent grouping of the sentences into paragraphs and chapters. Thus, much that is valuable or indispensable to the presumptive scientist is here compressed into very little space. My big question is whether anyone can really understand this book unless he already understands the subjects dealt with. To select a single example from among dozens of possibilities, I wonder just who is going to profit from being told that "when the investigator wishes to compare more than two means, he can use a method called analysis of variance, which represents an extension of the concept of standard deviation."

Perhaps courses can be designed to explain, illustrate, and amplify this skeleton of a text. For such specialized use, this book can be highly recommended to all who are presently handicapped by lack of a book like this.

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Punched Cards. Their applications to science and industry. Robert S. Casey, James W. Perry, Madeline M. Berry, Allen Kent, Eds. Reinhold, New York; Chapman and Hall, London, ed. 2, 1958. x + 697 pp. $15.

This second edition of *Punched Cards* is a substantially reworked edition. The largest portion of additional material appears in part 2, which recounts applications of punched cards, as in the first edition, without critical evaluation.

Like the first edition, this is largely an accumulation of material that is available elsewhere in published form, and a good deal of material is included that has only slight relationship to the subject of the book. Examples of this type of material are the article by E. J. Crane and Charles L. Bernier of Chemical Abstracts Service, dealing with indexing and index searching (chapter 24); this, while it is first rate, has little to do with punched cards, either internally punched for machine handling or edge-notched for manual handling. Similarly, chapter 26, by Byron A. Soule, deals with searching the literature and has little if any relationship to the subject of the book. Neither is Ascher Opler's article (chapter 29), dealing with electronic data processing machines, connected by any but the most remote relationship.

The bibliography on uses of punched cards (chapter 30) ranges the whole field of documentation, and the increase in number of references does not directly represent an increase in the punched-card literature. The bibliography includes a good many articles on electronic data-processing machines; photographic inputs for digital computers; the use of filmsort microfilm insert cards that may or may not be punched (those discussed in some of the articles cited are definitely not); Uniterm indexing with manual card matching (this again has nothing to do with punched cards); preparation of bibliographies by mounting typewritten slips; and many similar topics that are not related to punched cards.

The first edition, even though it was an expensive clip-and-paste job, was justified in the earlier stage of this art because it brought together a good deal of the industrial, technical, and machine operation material dealing with the notched-card and punched-card art. Since this has been done once, there does not appear to be much justification for a second edition which merely does somewhat more of the same, while retaining in large measure the first edition's lack of clarity, lack of sense of proportion, and lack of originality in the material presented.

This is a conglomeration of miscellaneous documentation materials, roughly clustered about the subject of punched cards, rather than a book. It lacks the synthesis, evaluation, and orderly presentation that would be necessary to make a substantive contribution, and it does little more than bind into one volume, at a high price, unevaluated material of varying pertinence, most of which is already available elsewhere.

RALPH R. SHAW
Graduate School of Library Service,
Rutgers University

L. L. U. Translations Bulletin. Department of Scientific and Industrial Research, London, 1959. 4s. 5d. (annual subscription, £2 13s.)

The purpose of the *L. L. U. Translation Bulletin* is to provide British scientists and engineers who are anxious to have details of current research in the U.S.S.R. with up-to-date information on the availability of Russian translations. It will be published monthly.

The *Bulletin* contains lists of books, journals, and other scientific papers which are now available or which are being translated and will become available in the near future. One section deals with cover-to-cover translations—a scheme for providing a complete Russian technical journal in the English language—and another gives details of the work being carried out by the National Science Foundation in the United States.

The *Bulletin* also contains articles on new scientific developments in the Soviet Union. It is contemplated that the *Bulletin* will cover other language translations in the near future.

Orders should be sent direct to Her Majesty's Stationery Office, P.O. Box 569, London, S.E.1.

New Books

Science in Schools. Proceedings of a Conference under the auspices of the British Association for the Advancement of Science held 17–18 April 1958 at the Royal Geological Society, London, S.W.7. W. H. Perkins, Ed. Butterworths, London, 1958 (order from Butterworths, Toronto 6, Canada). $3. (Reviewed in *Science* **128**, 1132, 1958.)

Social and Psychological Factors Affecting Fertility. vol. 5. Concluding reports and summary of chief findings from the Indianapolis study. P. K. Whelpton and Clyde V. Kiser. Milbank Memorial Fund, New York, 1958. 285 pp. $1.

Some Problems in Chemical Kinetics and Reactivity. vol. I. N. N. Semenov. Translated by Michel Boudart. Princeton Univ. Press, Princeton, N.J., 1958. 239 pp. $4.50.

The Stratigraphy of Western Australia. J. R. H. McWhae, P. E. Playford, A. W. Lindner, B. F. Glenister, B. E. Balme. Melbourne Univ. Press, Melbourne, Australia, 1958 (order from Cambridge Univ. Press, New York 22). 161 pp. $8.50.

Streptomycin and Dihydrostreptomycin. Antibiotics Monogr., No. 10. Louis Weinstein and N. Joel Ehrenkranz. Medical Encyclopedia, New York, 1958. 116 pp. $4.

Studies in Linear and Non-Linear Programming. Kenneth J. Arrow, Leonid Hurwicz, Hirofumi Uzawa. Stanford Univ. Press, Stanford, Calif., 1958. 229 pp. $7.50.

The Submicroscopic Organization and Function of Nerve Cells. Proceedings of the Symposium held 15–22 March 1957 by the Venezuelan Institute of Neurology and Brain Research, Caracas. Academic Press, New York, 1958. 644 pp. Cloth, $14; paper, $12.

Surface and Radiological Anatomy. For students and general practitioners. A. B. Appleton, W. J. Hamilton, Ivan C. C. Tchaperoff. Fourth edition by W. J. Hamilton and G. Simon. Williams & Wilkins, Baltimore, ed. 4, 1958. 355 pp. $9.50.

Ten Steps into Space. A series of lectures sponsored by the Franklin Institute, March–May 1958, in Philadelphia. Monogr. No. 6. Journal of the Franklin Inst., Philadelphia, Pa., 1958. 202 pp.

Reports

A Successor of Tepexpan Man in the Valley of Mexico

Abstract. A preceramic site at San Vicente Chicoloapan, in the Valley of Mexico, disclosed a human burial associated with stone-lined hearths and artifacts. The prevalence of primitive grinding stones suggests a collecting economy of the "Chalco culture," now for the first time recognized as such, and belonging to a long-headed people that succeeded Tepexpan Man some 8000 to 6000 years ago.

Ever since the discovery of Tepexpan Man (*1*) and of the corroborative evidence for early man in the adjoining site of Santa Isabel Iztapan (*2*), the Valley of Mexico has held out promise for bridging the hiatus between the mammoth hunters and the earliest farming cultures. The radiocarbon dates available for the two periods (9000 ± 100 and 3407 ± 250 years before the present) (*3*) suggested an approximate time span of some 5600 years for which no certain archeologic records were available. Scattered finds of basalt artifacts of distinctive typologic character indicated to me, as early as 1946, the presence of a preceramic culture provisionally named after the town of Chalco, where such artifacts were found in a calcareous evaporite of an ancient lake (*1*). Other finds were subsequently made in charcoal-bearing gravels which underlie the famous burial site of Tlatilco. In view of the ambiguous nature of the Chalco culture, it is therefore of interest to report on a new preceramic site in that region which clarifies the issue.

The circumstances which led to this new find were occasioned by an invitation which the Dirección de Prehistoria in Mexico extended to me last June to prospect for sites of early man and investigate related geologic features. The cordial assistance given me provided some welcome opportunities for studying various localities, among which is the new preceramic site here reported.

In 1955 a farmer had encountered human bones in his well excavation, close to the village of San Vicente Chicoloapan and adjacent to the highway which leads from Mexico City to Texcoco. The landowner intended to accord a Christian burial to these bones and consulted his priest, a Protestant minister, who had the good sense to deliver the cranium with an explanatory note to the Museo Nacional de Antropología e Historia. Since the museum authorities were not notified, the incident remained unknown until last year, when the cranium was noticed in the osteologic collection. When it was shown to me in the museum, I noticed how mineralized it was.

Upon my return from an excursion to Puebla, on 19 July, with Arturo Romano P., I visited the site of the find, a square pit measuring 3 m on each side and 3.60 m deep. The upper two meters had been protected by masonry. From one of the walls, close to the floor, projected a boulder. Next to it another, larger boulder had been found, which the owner put to use as a cover for the open well casing. We were told by the owner that both stones had lain on top of the skeletal remains at a depth of 3.42 m, a level indicated by the boulder still *in situ*. When we examined the soil layers at that level, we found a fragment of a human rib and next to it an obsidian flake. Sporadic bits of charcoal appeared at the same level. In the deepest portion, at 3.76 m, the pit disclosed a contact between the dark artifact-bearing soil and a plastic grey clay reminiscent of the swamp deposit in which the Tepexpan Man had been found. This contact between the lake deposit of late Pleistocene age and the old soil indicates that the burial had lain but 0.35 m above the lake clay which I took to represent the closing phase of a period in which mammoths roamed around the lake. One of these mammoths had in fact been found previously in such a stratum near the highway to Texcoco.

These observations prompted me to recommend an excavation, and, although the rainy season and other circumstances were anything but favorable, work was begun almost immediately. By the beginning of September, the time of my departure from Mexico, the original pit had been enlarged and the new area had been excavated to a depth of 3.50 m. The results of this first excavation may be summarized as follows.

Two meters distant from the burial, a fireplace was found, constructed of some 25 stones laid out in an elliptical heap measuring 0.84 by 0.53 m and containing small bits of charcoal. A few of the stones had been reddened by fire. A second, smaller hearth lay closer to the burial. In the same level, between 3.02 and 3.35 m, a number of basalt artifacts were encountered: crudely shaped grinding stones, metates and manos, two round stones a little larger than a baseball, flaked rocks, and a fair number of small obsidian chips, flakes, scrapers, and blades. One of the blades has a finely serrated edge. In the same level lay the broken basal portion of a large stemmed projectile point of chert. All the artifacts lay within a distance of 0.60 to 3 m from the original burial site. No sherds were encountered in this level; pottery fragments reached only to a depth of 2.55 m, at which level a laminated clay appeared lying on top of a thin layer of fine brown sand. Below this lay the compact sandy clay of dark color that contained the artifacts, fireplaces, and the burial.

A comparison of this soil sequence with others exposed in adjoining irrigation wells disclosed that the laminated clay layer is localized to the excavation site, indicative of sporadic ponding of meadows surrounding the Texcoco lake shore, which is at present some 2 miles distant from the site. The stratigraphic position of this ancient meadow soil is comparable to that of similar soils and stream deposits to which I had previously given the name Totolzingo phase (*1*). It was preceded by the lacustrine and delta deposits of the late glacial Becerra formation as represented by the plastic lake clay and by cross-bedded sands and clays which are exposed in a large sandpit 1 mile or so distant from the new site. The Becerra fauna is here represented by a skull of *Camelops*, a molar of an immature mammoth, and vertebrae of an extinct bison. Samples of the sediments encountered in the excavation were obtained by Monica Bopp, who intends to analyze their pollen content at Yale University.

In 1955 no other parts of the human skeleton from San Vicente Chicoloapan were preserved but the cranium. Its index (73.13), as determined by Arturo Romano P., indicates a long-headed type, different from that of Tepexpan Man, who was rather round-headed.

A tentative dating of the site may be

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* 125, 16 (1957)].

inferred from certain radiocarbon dates previously obtained from the Valley of Mexico (*4*). The charcoal from the Rio Hondo gravel at Tlatilco gave an average date of 6390 ± 300 years before the present for the Totolzingo phase. The date for the mammoth site at Santa Isabel Iztapan, near Tepexpan, as previously cited, is identical with one furnished last year by the Division of Geochemistry of the U.S. Geological Survey for the matrix of a giant fossil armadillo from the Upper Becerra formation (*5*). Its fauna may therefore have become extinct between 9000 and 8000 years ago. In view of the stratigraphic position of the burial at San Vicente Chicoloapan, its age may be 8000 to 6000 years.

The artifacts found so far have been deposited in the Direccíon de Prehistoria, which will continue the excavation (*6*).

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References and Notes

1. H. de Terra, J. Romero, T. D. Stewart, *Tepexpan Man* (Viking Fund Publ. Anthropol., No. 11, 1949).
2. L. Aveleyra A. de Anda, *El segundo mamut fósil de Santa Isabel Iztapan, Mexico, y artefactos associados* (*Instituto Nacional de Antropología e Historia*, Mexico D.F., 1955).
3. The latter date was supplied by J. L. Kulp of the Lamont Geological Observatory of Columbia University.
4. H. de Terra, "Comments on radiocarbon dates from Mexico," in F. Johnson, "Radiocarbon dating," *Am. Antiquity* 12, No. 1 (1951).
5. Information supplied by Ing. A. R. V. Arelleno of the Instituto Nacional de Geología in Mexico City.
6. Previous to my summer visit in Mexico I had the pleasure to attend, at the end of February, the opening of the Museo de Prehistoria at Tepexpan. Its simple but very attractive modern design provides a large hall, in the center of which is the original site of Tepexpan Man, surrounded by exhibition show cases, wall charts, and photographs. Situated on the road to the pyramids of Teotihuacan, a site frequented by thousands of visitors, it symbolizes the start of prehistoric studies in Mexico and the progress of public education in that country. The opening was among others attended by those Mexican colleagues to whom I feel deeply obliged for their generous aid and cooperation, notably Dr. Eusebio Davalos, professors P. Martinez del Rio and Arturo Romano P., and Luis Aveleyra A. de Anda.

4 November 1958

Antigenicity of Steroid-Protein Conjugates

Abstract. Testosterone, cortisone, deoxycorticosterone, estrone, and progesterone act as haptens when they are conjugated with bovine serum albumin. Antibodies with steroid specificity are formed in rabbits immunized with each of the five steroid hormone–protein conjugates.

Five steroid hormones, testosterone (T), cortisone (C), deoxycorticosterone (D), estrone (E), and progesterone (P), were coupled to bovine serum albumin (BSA) (Armour, fraction V). Six conjugates were formed, two containing testosterone, and one containing each of the other steroids. The conjugates are referred to as T-3-BSA, T-17-BSA, C-21-BSA, and so forth, the number indicating the carbon atom through which the steroid moiety was linked to the protein. The synthesis and chemical properties of T-3-BSA, T-17-BSA, and C-21-BSA have been described in detail (*1*). E-17-BSA, P-20-BSA, and T-3-BSA were prepared by use of the O-(carboxymethyl)-oxime. D-21-BSA was synthesized by use of succinate in a manner analogous to that used in the preparation of C-21-BSA.

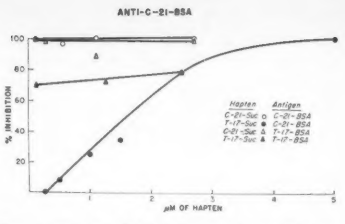

Fig. 1. The inhibition by cortisone-21-succinate and testosterone-17-succinate of precipitation of anti-C-21-BSA with C-21-BSA and T-17-BSA.

Antisera were obtained from rabbits immunized with alum-precipitates of each of the steroid-protein conjugates (*2*). All antisera precipitated with BSA as well as with the conjugate used for immunization. The antisera therefore were absorbed with BSA before use to eliminate that portion of the reactions between the conjugates and the antisera dependent on residual BSA specificity of the conjugates. Quantitative antibody determinations followed the procedure described by Kabat and Mayer (*2*), in which the Folin-Ciocalteu method (*3*) for analysis of the specific precipitates is used.

After absorption with BSA, it was found not only that the antisera react with the steroid-protein conjugate used for immunization, but also that cross-reactions among the steroid-protein conjugates also occurred. For example, at the respective points of maximal precipitation, D-21-BSA and P-20-BSA precipitated 67 percent, and T-3-BSA precipitated 50 percent, of the antibody from an anti-T-17-BSA serum precipitable by T-17-BSA.

The hapten-inhibition technique (*4*) has been used to demonstrate the steroid specificity of the antisera. In these studies, the steroid itself, as the hemisuccinate or the O-(carboxymethyl)oxime, was incubated with the antiserum prior to the addition of the homologous antigen. The effectiveness of each hapten in inhibiting precipitation could be calculated by comparing the precipitate formed in the presence of the hapten with the precipitate formed without the hapten. The results shown in Table 1 indicate that each antigen-antibody system was inhibited by the homologous hapten and so demonstrate the steroid-specificity of the antisera.

The specificity of the reaction between antigen and antibody is also indicated from a comparison of the inhibiting effectiveness of T-17-hemisuccinate with the homologous hapten. As is shown in Table 1, for each system where this has been done, the homologous hapten is a better inhibitor than T-17-hemisuccinate.

The hapten-inhibition technique may also be used to elucidate the chemical basis for the specificity of the antisteroid sera by determination of the inhibitory effectiveness of a large number of haptens. The results of some experiments designed to determine the specificity of anti-T-17-BSA are recorded in Table 2. As with the other antisera, the homologous hapten, in this case T-17-hemisuccinate, was a better inhibitor than any of the other haptens studied. Compound S-21-succinate, which differs from T-17-succinate by possessing a dihydroxy side

Table 1. Inhibition of the reactions between the steroid-protein conjugates and their homologous antisera by the homologous hapten and testosterone-17-succinate. Suc, succinate, OCMO, O-(carboxymethyl)oxime.

Antiserum	Hapten	Amt. (mg)	Inhibition (%)
T-17-BSA	T-17-Suc	0.1	74
T- 3-BSA	T-3-OCMO	0.1	58
T- 3-BSA	T-17-Suc	0.5	25
C-21-BSA	C-21-Suc	0.05	93
C-21-BSA	T-17-Suc	0.5	55
D-21-BSA	D-21-Suc	0.01	90
D-21-BSA	T-17-Suc	0.1	80
P-20-BSA	P-20-BSA	0.005	80
E-17-BSA	E-17-OCMO	0.1	96
E-17-BSA	T-17-Suc	0.5	77

Table 2. Inhibition of the reaction between T-17-BSA and anti-T-17-BSA by various soluble steroid derivatives. Suc, succinate; OCMO, O-(carboxymethyl) oxime.

Hapten	Amt. (mg)	Inhibition (%)
T-17-Suc	0.1	74
Compd. S-21-Suc	0.1	66
C-21-Suc	0.2	63
Hydrocortisone-21-Suc	0.1	36
T-3-OCMO	0.1	12
E-17-OCMO	0.2	4
Estradiol-17-Suc	0.2	0

chain at C-17, is almost as effective an inhibitor. The effect of substitution at the 11-position depends upon the nature of the oxygen function. The presence of a ketone group at C-11, as in cortisone-21-succinate, does not decrease inhibitory activity as much as does a C_{11}-β-OH group, such as is present in hydrocortisone-21-succinate. Alteration in the A ring, either by formation of a derivative at C-3 [testosterone-3-O-(carboxymethyl)oxime] or by aromatization of the ring (estrone and estradiol), greatly decreases or abolishes inhibitory activity. It would appear, from these results, that the structural features of ring A, that portion of the hapten molecule which is furthest removed from the point of attachment to the BSA, determines, to a great extent, the specificity of the reaction between T-17-BSA and anti-T-17-BSA. It is expected that continuation of studies of this type, by use of additional soluble steroid derivatives, will reveal more precisely the chemical basis of specificity.

An interesting example of specificity is depicted in Fig. 1, in which the inhibiting effectiveness of T-17-succinate and C-21-succinate on the reactions of C-21-BSA and T-17-BSA with an antiserum to C-21-BSA are plotted. C-21-succinate, the homologous hapten, equally inhibits the reaction with the homologous antigen, C-21-BSA, and the heterologous antigen, T-17-BSA. On the other hand, the heterologous hapten, T-17-succinate, inhibits the cross-reaction with T-17-BSA much better than it inhibits the reaction with the homologous antigen, C-21-BSA. Thus, although anti-C-21-BSA cross-reacts with T-17-BSA, by addition of a suitable concentration of T-17-succinate it should be possible to inhibit practically completely the cross-reaction with negligible effect on the homologous reaction. It is hoped that, in this manner, the in vivo activity of anti-C-21-BSA may be studied without complicating cross-reactions, and such investigations are now in progress.

It has thus been demonstrated that several steroid hormones may act as haptens when coupled to a protein, and antibodies with steroid specificity may be elicited (*5*).

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17 September 1958

Vanguard Measurements Give Pear-Shaped Component of Earth's Figure

The determination of the orbit of the Vanguard satellite, 1958β_2, has revealed the existence of periodic variations in the eccentricity of that satellite (*1*). Our calculations indicate that the periodic changes in eccentricity can be explained by the presence of a third zonal harmonic in the earth's gravitational field. The third zonal harmonic modifies the geoid toward the shape of a pear. In the present case, the stem of the pear is up—that is, at the North Pole. According to our analysis, the amplitude of the third zonal harmonic is 0.0047 cm/sec² in the surface acceleration of gravity, or 15 meters of undulation in the geoid.

Figure 1 shows the observed variation in eccentricity. The period of the variation in eccentricity is 80 days, approximately equal to the period of revolution of the lines of apsides. The eccentricity is a maximum when the perigee is in the Northern Hemisphere. The amplitude of the variation is 0.00042 ± 0.00003. Similar perturbations may exist in the angle of inclination of the orbit, although the data for them are much less accurate. No perturbations of this magnitude appear to exist in the semimajor axis.

In principle, the perturbation might be caused by both odd and even harmonics. However, the even harmonics can be excluded because the observed effect has opposite signs in the Northern and Southern hemispheres. Furthermore, we can also exclude tesseral harmonics (those which depend on longitude as well as latitude) because these also are the same in the Northern and Southern hemispheres, apart from a shift in longitude. We are left with the zonal harmonics (those which depend only on latitude) of odd degree.

Of the odd zonal harmonics, the first degree is forbidden; and those of higher degree are unlikely to have a large effect because they die out inversely as the $(n+1)$ power of the distance. The effect is therefore due mostly to the third zonal harmonic, with a possible contribution from the fifth.

Accordingly, a calculation was made of the effect of the third zonal harmonic on the orbit elements of 1958β_2, by methods developed by O'Keefe and Batchlor (*2*). In the resultant expression for the eccentricity, the dominant terms were those whose argument was the mean motion of perigee. These were larger than the others by a factor of 10^3. Keeping only the large terms, we find

$$e = e_0 + \frac{3}{2} A_{3,0} \frac{(1-e^2)^{1/2}}{na^6} \frac{1}{n'} \times \sin i \left(1 - \frac{5}{4}\sin^2 i\right) \sin \omega \qquad (1)$$

where $A_{3,0}$ represents the coefficient of the third zonal harmonic in the notation of Jeffreys (*3*), n is the orbital mean motion and n' is the mean motion of the perigee, e is the eccentricity and e_0 the mean eccentricity, i is the angle of inclination, ω is the argument of perigee, and a is the semimajor axis.

Setting in the constants of the orbit and the observed amplitude of e, we find

$$A_{3,0} = (2.5 \pm 0.2) \times 10^{20} \qquad (2a)$$

in meter-second units. Utilizing the relation given by Jeffreys,

$$A_{n,s} = \frac{c^{n+2}}{n-1} g_{n,s}$$

(where $A_{n,s}$ is the coefficient of the disturbing potential, $g_{n,s}$ is the acceleration of gravity at the surface of the earth, and c is the earth's equatorial radius), we find that the third zonal harmonic of gravity at the earth's surface, in milligals, is

$$g_{3,0} = 4.7 \pm 0.4 \qquad (2b)$$

Equation 2 is relevant to what Vening Meinesz (*4*) and Heiskanen call the "basic hypothesis of geodesy." These authors assume that the earth's gravitational field is very nearly that of a fluid in equilibrium. They consider that the deviations from such an ellipsoid, in any given area, do not exceed about 30 milligal-megameter units—that is, they assume that one will not find deviations of more than 30 milligals over an area of 1000 kilometers on a side, or deviations of more than 3 milligals in an area 3000 kilometers on a side.

Our determination of the third-degree zonal harmonic shows that the hypothesis of Vening Meinesz and Heiskanen is

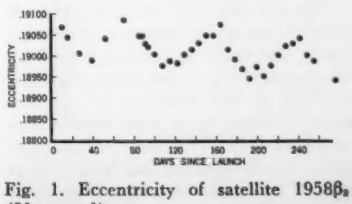

Fig. 1. Eccentricity of satellite 1958β_2 (Vanguard).

not justified; for example, each of the polar areas has a value of about 120 milligal-megameters, and each of the equatorial belts a value more than twice as great.

The presence of a third harmonic of the amplitude (*2*) indicates a very substantial load on the surface of the earth. Following the arguments of Jeffreys, we may calculate the values of this load and the minimum stress required in the interior to support it. We find a crustal load of 2×10^7 dy/cm². We can choose between assuming that stresses of approximately this order of magnitude exist down to the core of the earth, or that stresses of about 4 times that amount exist in the uppermost 700 kilometers only (*3*, p. 199). These stresses must be supported either by a mechanical strength larger than that usually assumed for the interior of the earth or by large-scale convection currents in the mantle (*5*).

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27 January 1959

Synchronized Cell Division and DNA Synthesis in a Lactobacillus Acidophilus Mutant

Abstract. Withdrawal and subsequent restoration of deoxyriboside to a deoxyriboside-requiring mutant leads to synchronous cell division. There is a time lag between restoration and the first synchronous division; during this time the amount of deoxyribonucleic acid (DNA) per cell increases in stepwise fashion, and mass per cell increases linearly with time. The onset of cell division is heralded by cessation of DNA synthesis and an abrupt increase in rate of mass synthesis.

The intracellular events leading to cell division are under intensive study currently, and many approaches have been employed. One of the most promising methods is the induction of synchronized division in a population whose members normally divide randomly in time. Synchronization has been accomplished by means of temperature shifts (*1*), fractionation of cell popoulations (*2*), and addition of thymine to a thymineless *Escherichia coli* mutant (*3*). All methods are subject to the objection that the process of induction may produce abnormal divisions, and that the biochemical events preceding these divisions may have no relation to those preceding normal divisions. This objection can be overcome partly by comparison of results from as many methods of synchronization as possible and by use of a method which has specific and reasonably predictable biochemical effects.

The method described here (*4*) employs a mutant with a block at the deoxyriboside level of DNA synthesis, and synchronization is accomplished by withholding deoxyriboside from otherwise normally nourished cells and subsequently restoring it. The direct effect of this method is specific inhibition of DNA synthesis; the indirect effect of inhibition of DNA synthesis is small during the period of abnormal nutrition, as judged by high viability and continuing growth in the present instance. Ribonucleic acid synthesis continues in the absence of DNA synthesis (*5*). A major indirect effect is, of course, inhibition of cell division.

The mutant strain employed in these studies was *Lactobacillus acidophilus* R26. This strain grows in synthetic medium and has a specific requirement for deoxyriboside or deoxyribotide. Hoff-Jorgensen (*6*) has used this mutant for quantitative bioassay of DNA. The synthetic medium (LSM) was the same as Hoff-Jorgensen's, but with the addition of 10 mg of uracil and 0.5 mg of pyridoxine per liter, as suggested by Siedler *et al.* (*7*). Thymidine was used to satisfy the deoxyriboside requirement. Where indicated, thymidine was supplied at a concentration of $3 \times 10^{-6} M$, an amount just sufficient to give maximum growth.

For the majority of experiments, cells were prepared by growing them for 16 hours in LSM with thymidine. These cells were harvested, washed, and suspended at about 10^7 cells per milliliter in synthetic medium lacking thymidine. The suspension was stirred at 37°C, and aliquots were withdrawn for viable cell counts and turbidity and DNA determinations. Viable cell counts were made by the indirect method; suitably diluted aliquots were plated on nutrient agar, and the number of viable cells per milliliter was determined from colony counts. Turbidity measurements provide a direct estimate of cell mass rather than of number of cells (*8*). Turbidity (optical density at 500 mμ in the range of 0 to 0.4) was found experimentally to be proportional to cell protein per milliliter (determined by the Folin phenol method), irrespective of cell size. This is important because the cells elongate during thymidine starvation and break up into smaller units when division starts. Deoxyribonucleic acid determinations were made by the Ceriotti method as modified by Keck (*9*). Cells were washed twice in cold 5-percent trichloroacetic acid and extracted in hot trichloroacetic acid, and the extract was analyzed for DNA.

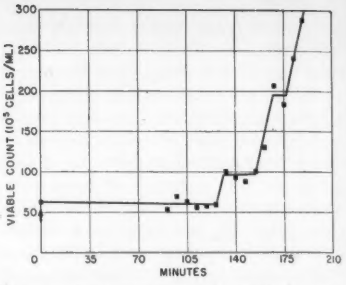

Fig. 1. Synchronous cell division. The time of addition of thymidine is indicated by the arrow.

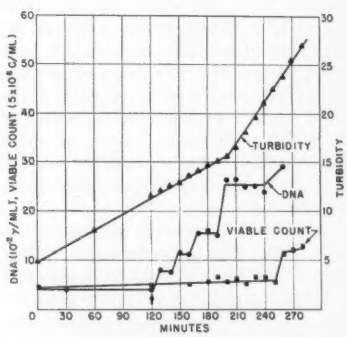

Fig. 2. Variation of DNA, turbidity, and viable cell count with time in a synchronized culture. Incubation in the absence of thymidine started at time 0; addition of thymidine is indicated by the arrow.

Figure 1 shows two cycles of synchronous division. The cells were incubated in the absence of thymidine for 3 hours, then thymidine was added, at time 0 in the figure. There is a lag of about 2 hours before the first division. Two or three synchronous divisions follow the lag in rapid succession, the later ones being less distinct than the earlier. One synchronous division cycle takes about 30 minutes, which is much less than the 1½-hour generation time of nonsynchronous log phase cells.

Viability as a function of time during the course of starvation for thymidine has been determined, but the curve is omitted here for brevity. Death, presumably due to "unbalanced growth" (*3*), begins to appear only after 5 or 6 hours' starvation, if excessive aeration is avoided.

Figure 2 shows the results of simultaneous determinations of DNA, turbidity, and viable cell count. There is no net synthesis of DNA in the absence of

deoxyriboside, but synthesis starts immediately after addition of thymidine and proceeds stepwise. Three to four steps, followed by a long cessation of synthesis immediately prior to the first synchronous division, have appeared in all repetitions of this experiment. Deoxyribonucleic acid increases four- to eightfold before the first division. This is in line with the results of Jeener and Jeener (*5*), who demonstrated, by staining this mutant under conditions of deoxyriboside starvation and reactivation, that the cells can have many more than the normal two nuclei before they begin dividing. The fact that DNA more than doubles before division probably means, then, that the number of nuclei per cell more than doubles. On this basis the steps in the DNA curve may represent nuclear divisions. The appearance of cell division is correlated not with the amount of DNA multiplication, which is variable, but with the temporary cessation of DNA synthesis.

Well before the first division and at about the time of appearance of the DNA plateau, the rate of cell mass synthesis, as measured by turbidity, abruptly triples or quadruples and continues at the new rate through the first division cycle. Cell mass is synthesized linearly with time, rather than exponentially, throughout both the starvation and the reactivation phases. It is evident that the linear rate and the abrupt shift from one rate to another are similar to the results of mass measurements of single *Schizosaccharomyces* cells (*10*) if it is kept in mind that division may begin well before the daughter cells separate to form two viable units. It is tempting to assume that the simultaneous cessation of DNA synthesis and increase in the rate of protein synthesis are coordinated and decisive events in the sequence leading to cell division.

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30 September 1958

Cholecystokinin Activity of Urine

Abstract. In the urine of men and animals was found a factor which evokes the contraction of the gall bladder. This factor increases in the urine after the application of a secretogenous stimulus to the duodenum and decreases after resection of the duodenum. A urine concentrate was prepared which has an effect similar to that of cholecystokinin administered intravenously and which was therefore called urocholecystokinin.

Ivy and Oldberg (*1*) reported the isolation of cholecystokinin from the duodenal mucosa. Intravenous administration of this hormone leads to contraction of the gall bladder without alteration of the blood pressure.

In assays on dog gall bladder *in situ* (*2*) and on guinea pig gall bladder *in situ* (*3*) I found that human urine injected intravenously also caused contraction of the gall bladder. Urine from a healthy fasting person evoked less contraction of the gall bladder than the same amount of urine from the same person after a fat-containing meal (Tables 1 and 2). Vagotomy of the experimental animal did not alter these results.

One milliliter of urine from duodenectomized guinea pigs caused less contraction of the gall bladder in the assay on guinea pigs than 1 ml of urine from normal control guinea pigs (Table 2). One milliliter of urine from guinea pigs given 1 ml of 0.1*N* HCl in the duodenum caused a greater contraction of the gall bladder than 1 ml of the urine from control guinea pigs.

The urine factor which evokes the contraction of the gall bladder can be adsorbed on benzoic acid (*4*). This method was modified in the following way: To 10 lit. of urine was added, drop by drop, 1.5 lit. of saturated ethanolic solution of benzoic acid. The precipitate formed was filtered off, and 1.5 lit. of acetone was added in order to dissolve the benzoic acid that was present. After further purification the precipitate was dried and pulverized. The dry powder was dissolved in physiological saline solution, at *p*H 3, and was administered intravenously.

The concentrates eluted from the benzoic acid did not alter the blood pressure. The urine factor causing the gall bladder contraction is thermolabile and does not stimulate duodenal motility.

These experiments show that there is evidence of a relation between cholecystokinin, Sandblom's blood factor (*5*), and the urine factor that evokes contrac-

Table 1. Assay on dog gall bladder *in situ*.

Material	Quantity	Intragall-bladder pressure level* (cm)	Standard error of the mean	No. of tests
Human urine from fasting persons	10 ml	0.7	± 1.6	15
Human urine from persons 2 hr after drinking 50 ml of olive oil	10 ml	1.1	± 0.25	6
Urocholecystokinin (benzoic acid adsorbate from human urine)	50 mg	0.8	± 0.18	14
Urocholecystokinin (benzoic acid adsorbate from human urine)	100 mg	1.5	± 0.17	14

* Water manometer.

Table 2. Assay on guinea pig gall bladder *in situ*.

Material	Quantity	Intragall-bladder pressure level* (cm)	Standard error of the mean	No. of tests
Human urine from fasting persons	1 ml	1.8	± 0.3	40
Human urine from persons 2 hr after drinking 50 ml of olive oil	1 ml	3.0	± 0.27	10
Urine from normal guinea pig	1 ml	4.2	± 0.32	12
Urine from duodenectomized guinea pig	1 ml	3.5	± 0.38	7
Urine from guinea pig given 1 ml of 0.1*N* HCl in the duodenum	1 ml	5.4	± 0.35	8
Urocholecystokinin (benzoic acid adsorbate from human urine)	5 mg	3.4	± 0.26	10
Urocholecystokinin (benzoic acid adsorbate from human urine)	10 mg	6.5	± 0.28	10

* Elevation of the gall in the pipette.

tion of the gall bladder. In the experiments in which the duodenum is stimulated to secrete more cholecystokinin through the administration of hydrochloric acid, the concentration of the gall-bladder–contracting factor in the urine is higher. If the chief source of cholecystokinin is excluded by duodenectomy, the concentration of the gall-bladder-contracting factor in the urine is lower.

Greengard *et al.* (*6*) showed that the blood serum inactivates cholecystokinin. As more than 120 minutes are necessary for total inactivation, it is possible that cholecystokinin reaches the kidneys in an active form.

The term *urocholecystokinin* is suggested for the factor, present in urine, which causes contraction of the gall bladder without altering the blood pressure and duodenal motility.

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25 July 1958

Metabolic Dissociation of Short-Lived Barium-137m from Its Cesium-137 Parent

Abstract. At 4 to 7 days after Cs^{137} administration, Ba^{137m} was found to exceed Cs^{137}-Ba^{137m} equilibrium proportions in bone and plasma by factors of 3 and 14, respectively, in the living animal. This demonstrated the in vivo escape of Ba^{137m} from sites of Cs^{137} accumulation. Liver tissue was slightly deficient in Ba^{137m}, whereas tissues such as bone marrow and spleen showed little or no deviation from equilibrium.

Cesium-137 is one of the more important potential hazards of fallout. Although the metabolism of radiocesium in biological systems has been studied in appreciable detail (*1*), no consideration has been given to the consequences of the differential behavior of Ba^{137m}, the radioactive daughter of Cs^{137}. The decay scheme is as follows:

$$Cs^{137} \xrightarrow[T\frac{1}{2} = 33\ yr]{0.52\text{-Mev } \beta} Ba^{137m} \xrightarrow[T\frac{1}{2} = 2.6\ min]{0.66\text{-Mev } \gamma} Ba^{137}$$

Cesium-137 decays by beta emission with a 33-year half-life to Ba^{137m} which in turn decays by gamma emission with a half-life of 2.6 minutes to a stable state.

In the organism, Cs^{137} would be expected to have a metabolic behavior similar to that of potassium, as both are alkali metals; Ba^{137m}, however, would be expected to behave more like the other alkaline earths, calcium and strontium (*2*). The metabolic dissociation of Ba^{137m} from the parent Cs^{137} has probably been overlooked experimentally because tissues are usually not measured within minutes after removal from the organism; this delay permits the reestablishment of equilibrium conditions in the tissue samples (the rate of establishment of equilibrium is governed by the half-life of the daughter, 2.6 minutes).

In the work reported here (*3*), the observations were made within minutes after removal of tissues; this permitted an estimation of the differential behavior of parent and daughter and an evaluation of the concentrations of the isotopes as they exist in the living animal.

Twelve normal albino rats of body weight about 150 g were injected intraperitoneally with about 60 μc of Cs^{137}-Ba^{137m}. At 4 to 7 days, the rats were anesthetized with sodium pentobarbital, and samples of blood, bone, and liver were removed from the living animal for radioassay. For each sample, an accurate time record was kept, starting at the time of removal from the body. The whole blood and liver were placed directly in test tubes, and radioactivity measurements were started within 1 to 2 minutes after removal. The femur diaphysis was used for the bone sample and was cleaned of extraneous tissue and marrow as rapidly as possible; measurements were usually started about 2 minutes after removal. Three blood samples were drawn into hematocrit capillaries, centrifuged, and the plasma and red blood cells separated so that radioassay was started on each fraction about 4 minutes after removal of blood from the animal. The samples were all counted in the usual well-type scintillation detector. In order to follow the expected decay or growth, a count-rate meter was employed with a recorder to give continuous reading of the counting rate over the 10 to 20 minutes required for attainment of equilibrium. Tissue weights were obtained after completion of the radioactivity measurements. The values given for liver and blood represent an average of tissues from four animals and, for bone, an average of tissues from eight animals. The results are expressed as follows: A, observed counts per minute per milligram of tissue; A_{eq}, counts per minute per milligram of tissue at equilibrium.

The observed radioactivities (A) in the various tissue samples as a function of time after removal from the body are presented as a semilog plot in Fig. 1. It is immediately apparent that the gamma activity in bone and blood decreased markedly with time to an equilibrium value, whereas that in liver increased slightly. Graphic analysis of these curves indicated that they represented two exponential rate processes: there was a short-lived component and a component of long enough half-life that decay could be neglected over this time scale. The short half-life was calculated in the usual way by plotting A–A_{eq} (irrespective of sign) versus time on a semilog scale (Fig. 1). As expected, a half-life of about 2.5 minutes for blood, bone, and liver was obtained; this is in agreement with that reported for Ba^{137m}.

The observations on plasma and erythrocytes are presented in Fig. 2. For convenience, the values are expressed in terms of A/A_{eq}. It is obvious that there was no appreciable change in the radioactivity of the red blood cells during the 20-minute counting period; the possible slight decline at the early time periods may have been caused by trapped plasma. The radioactivity in the plasma, however, decreased significantly with time, with a half-life of about 2.7 minutes.

There is little question that the Ba^{137m}

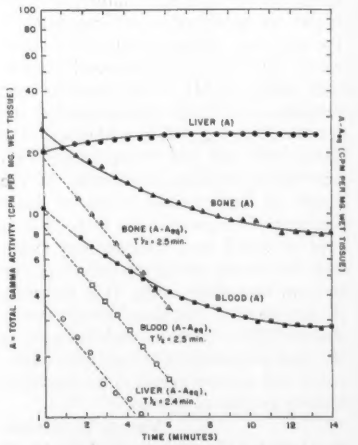
LIVER (A)
BONE (A)
BONE (A-Aeq), T½ = 2.5 min.
BLOOD (A)
BLOOD (A-Aeq), T½ = 2.5 min.
LIVER (A-Aeq), T½ = 2.4 min.
A = TOTAL GAMMA ACTIVITY (CPM PER MG WET TISSUE)
A-Aeq (CPM PER MG WET TISSUE)
TIME (MINUTES)

Fig. 1. Change in the total gamma activity (A) in liver, bone, and blood after removal from rats previously injected with Cs^{137}-Ba^{137m}, and the plot of their corresponding short-lived component ($A - A_{eq}$) with calculated halftimes ($T\frac{1}{2}$) given.

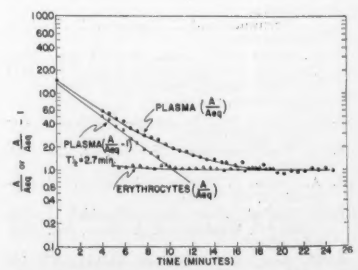

Fig. 2. Partition of excess Ba^{137m} between plasma and erythrocytes in the rat (see text for definition of terms).

daughter produced within the body from Cs^{137} is differentially metabolized so that, in the living animal, various tissues may have a deficiency or excess of Ba^{137m} as compared with the equilibrium mixture. It can be calculated from the data presented thus far that the gamma levels in the liver, bone, blood, and plasma of living animals in these experiments were 0.8, 3.3, 3.9 and 14 times the values as determined by usual tissue analysis.

In another study, other tissues were examined by the same procedure to see whether there was an excess or deficiency of Ba^{137m}. It was observed that the gamma activity in blood and bone decreased with time as noted before. No deviations from the equilibrium proportions were seen for bone marrow, testes, and brain; there was a suggestion of an excess Ba^{137m} in spleen and a deficiency of Ba^{137m} in kidney. The significance of these results is obscured because of the difficulty of detecting slight deviations from equilibrium against the high levels of Cs^{137}-Ba^{137m} in these tissues.

The source of excess Ba^{137m} in the plasma is most likely the soft tissues. Although the red blood cells probably contribute to the plasma excess, they can only be a minor source since the blood as a whole shows a considerable excess of the Ba^{137m}. The excess of Ba^{137m} in bone is probably the result of two mechanisms: a reflection of the increased plasma levels and a selective accumulation of barium by the bone. Evidently any depletion of the plasma barium by selective accumulation in bone is far outweighed by the entry of barium into the plasma from the tissues.

The fact that there is an excess or deficiency of Ba^{137m} in the living animal and that it can be measured raises some interesting considerations: (i) Since the gamma activities in tissues of the living animal are different from those expected from usual radioassay procedures, the radiation dosage may be different from that calculated from available Cs^{137} levels. (ii) Barium-137m is produced within cells and the opportunity is presented for studying the mechanism by means of which this element is extruded from the cell. (iii) Steady-state levels of Ba^{137m} in clinical cases after Cs^{137} administration may indicate both the state of the circulatory system and tissue metabolism; these factors, among others, should influence the level of excess Ba^{137m} in the blood. (iv) The excess Ba^{137m} in the skeleton offers the possibility of studying the processes of rapid incorporation of alkaline earths into bone independent of the slower process of growth. For example, from a comparison of the excess Ba^{137m} to calcium ratios in the plasma and bone, it was calculated that the exchangeable calcium in the femur diaphyses was 4 to 5 percent; this is in general agreement with other values in the literature as determined by other methods (*4*).

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18 September 1958

Effects of Thyroxin on Amino Acid Incorporation into Protein

Abstract. The effect of thyroxin on the in vitro incorporation of DL-leucine-1-C^{14} into the protein of rat liver homogenates has been investigated. Both thyroxin pretreatment in vivo and thyroxin in vitro at a concentration of $1 \times 10^{-5}M$ were found to increase the rate of amino acid incorporation. The increased activity following the thyroxin pretreatment in vivo was found to be localized in the mitochondrial fraction. It is suggested that the acceleration of metabolic rate characteristic of thyroxin action may be secondary to the stimulation of energy-requiring reactions such as protein synthesis.

Recent concepts of the mechanism of action of thyroxin have emphasized its uncoupling effect on oxidative phosphorylation (*1*, *2*). This effect, however, is observed only with relatively high concentrations of thyroxin, occurs equally well with both the D- and L- forms (*1*), and, except for changes in oxidative metabolism, explains few of the physiological effects of the thyroid hormone. Many clinical features of thyroid disease suggest a major, if not primary, role of the thyroid hormone in protein metabolism. In immature animals it is involved in growth; in adults it causes pronounced changes in nitrogen metabolism. Furthermore, in the adult brain and testis—organs in which the quantities of protein and lipid turned over per unit time are apparently negligible compared with turnover of carbohydrate, as evidenced by a respiratory quotient of approximately 1 (*3*)—the characteristic acceleration of metabolic rate that is observed in almost all other tissues is absent in hyperthyroidism (*4*).

Previous observations (*5*) have indicated that thyroxin pretreatment in vivo stimulates amino acid uptake into the protein of rat liver slices. To investigate further the apparent relationship between thyroid function and protein synthesis, studies were undertaken to determine the effects of in vivo and in vitro thyroxin administration on the in vitro incorporation of DL-leucine-1-C^{14} into the proteins of rat liver homogenates. Livers from 90- to 150-g fasting, male Sprague-Dawley rats were homogenized by means of glass homogenizers in 5 ml of $0.25M$ sucrose solution per gram of tissue. Homogenization was performed at 0° to 2°C, and tissue fractions were maintained at that temperature through all subsequent operations until final incubation. Intact cells, nuclei, and cell debris were removed by centrifugation at 700*g* for 10 minutes. The supernatant fluid was spun at 54,000*g* for 60 minutes in a Spinco model L ultracentrifuge. The

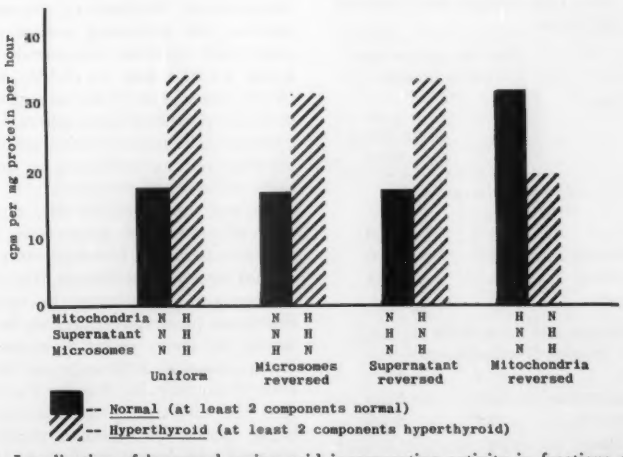

Fig. 1. Localization of increased amino acid incorporating activity in fractions of liver homogenates from rats pretreated with thyroxin. Results are representative of seven such experiments.

sediment, containing both mitochondrial and microsomal fractions, was suspended in appropriate amounts of 0.25*M* sucrose and supernatant fluid to yield a suspension containing particulate fractions and supernatant fluid equivalent to approximately 200 mg and 30 mg of liver, respectively, per 0.45 ml, the quantity of homogenate added to each of the experimental flasks.

In eight experiments rats were paired for age and weight; one received almost daily intraperitoneal injections of 100 μg of sodium thyroxin in 1 ml of 0.01*N* NaOH; the other received equivalent amounts of the NaOH solution alone. After at least six doses in 7 days, homogenates were prepared simultaneously from both animals as described above, and DL-leucine-1-C^{14} incorporation activity in both was measured in parallel flasks in a single combined experiment. Flask contents and incubation procedure are described in the title of Table 1. The reaction was terminated with 12-percent trichloroacetic acid, and the precipitated protein was purified and plated on filter paper by a modification of the method of Siekevitz (*6*). Sample weights were determined from difference in planchet weights before and after plating. Radioactivity was measured with a thin-window Geiger-Mueller counter; total counts collected were sufficient to yield a 3-percent coefficient of variation. Counting rates were corrected for background, self-absorption, and zero time controls. The results are summarized in Table 1. Although protein nitrogen concentrations, as determined by the micro-Kjeldahl technique, were identical in both groups (2.17 mg per flask), leucine incorporation was substantially greater in the homogenates from thyroxin-treated rats.

Table 1. Effects of thyroxin on DL-leucine-1-C^{14} incorporation into protein of rat-liver homogenates. To each flask (25-ml Erlenmeyer) were added 5 μmole of adenosine-5′-monophosphate, 20 μmole of potassium phosphate (*p*H 7.4), 5 μmole of $MgCl_2$, 50 μmole of potassium α-ketoglutarate, 0.8 μmole of DL-leucine-1-C^{14} (specific activity, 5.33 μc/μmole), and 0.45 ml of the appropriate homogenate prepared in 0.25*M* sucrose, as described in the text. In in vitro studies, 0.022 μmole of sodium thyroxin contained in 0.1 ml of 0.01*N* NaOH was added to the experimental flasks; all other flasks received equivalent amounts of the NaOH solution alone. The reaction mixture was brought to a final volume of 1.7 ml with 0.25*M* sucrose. Incubation in air was carried out with shaking in a water bath at 37°C for 1 hour. Zero time controls were included in all experiments.

Item	Activity (count/min mg of protein per hr)	
	Mean	Standard error
Thyroxin pretreatment in vivo (8 rat pairs)		
Normal rat	29.0	±1.9
Hyperthyroid rat	42.3	±3.0
Difference	13.3*	±3.2
Effect (%)	+46	
Treatment with 1.3×10^{-4}M thyroxin in vitro (7 experiments)		
Control	26.9	±1.8
Thyroxin-treated	31.9	±2.3
Difference	5.0*	±1.4
Effect (%)	+19	

* Denotes statistical significance; $p < .02$ (determined by method of paired comparison).

In order to localize the source of the increased activity, mitochondria and microsomes were prepared separately from livers of both types of animals by centrifugation at 15,000*g* for 15 to 20 minutes and 105,000*g* for 60 minutes, respectively. All possible combinations of mitochondria, microsomes, and supernatant derived from both homogenates were incubated as described above. Representative results of an experiment of this type are illustrated graphically in Fig. 1. It is clear that most, if not all, of the increased activity is localized in the mitochondrial (15,000*g*) fraction.

In Table 1 are also summarized the results of seven experiments in which the effects of $1.3 \times 10^{-5}M$ thyroxin added in vitro to normal rat liver homogenates were studied under the conditions specified. Although less pronounced, the effects were just as consistent as those observed with thyroxin administration in vivo, a stimulation occurring in every one of the experiments. Similar effects have been observed in several experiments with slightly altered conditions. The effect is erratic with more highly concentrated homogenates and is completely eliminated by doubling the Mg^{++} concentration. Preliminary observations indicate that increasing graded effects occur with thyroxin concentrations between 1×10^{-7} and $1 \times 10^{-4}M$. At $1 \times 10^{-3}M$, the effects of the uncoupling of oxidative phosphorylation supersede, and a marked inhibition of amino acid incorporation occurs, indicating a qualitatively different phenomenon.

To test the possibility that the thyroxin effects may be preservative rather than stimulatory, a few short-term incubations have been performed. The effects of thyroxin pretreatment in vivo are clearly not preservative; they are as great during the linear period of amino acid incorporation as at 60 minutes. The effects of thyroxin in vitro are less clear; they are distinctly present during the linear period but become more pronounced with longer incubation.

The results of these studies (*7*) suggest that uncoupling of oxidative phosphorylation is not a physiological action of thyroxin. They support, rather, the hypothesis that thyroxin stimulates energy-requiring processes, such as protein synthesis, and that its characteristic acceleration of oxygen consumption is secondary to the increased demand.

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21 August 1958

Serial Errors in Human Learning: a Test of the McCrary-Hunter Hypothesis

Abstract. An experiment was conducted on 120 human subjects to test the hypothesis that the probability distribution of serial errors is an invariant property of rote memorization. Contrary to the hypothesis, the relative difficulty function was significantly affected by ability to learn. There was a systematic tendency ($p < .05$) for fast learners to commit proportionately more errors in the middle of the sequence.

The present communication reports an experimental test (*1*) of a hypothesis concerning certain learning phenomena advanced by McCrary and Hunter (*2*). Upon reexamining many classical serial position curves, in which distribution of practice had caused unequal reductions in errors at the central and extreme positions of a list, McCrary and Hunter conceived the idea of employing *relative* rather than *absolute* measures of difficulty. To this end, they replotted some earlier data by expressing the mean errors committed at each serial position "as a percentage of the total mean errors" (*2*). The results were as follows: (i) all curves had the typical skewed, bowed form which reveals subjects' greater difficulty with intermediate items than with initial or final items, and (ii) all curves had basically the same form, showing no consistent differences in trend under variation of work conditions.

From these findings, McCrary and

Hunter proceeded to an experiment in which 16 subjects memorized lists of nonsense syllables or familiar names. In contrast with the two divergent mean error curves, the percentage error curves appeared to coincide, as in the case of the distributed-practice data. However, when similar graphs were made of the performance of fast versus slow learners ($n = 8$ each) on the easier list, there was a tendency for the fast learners to make *proportionately* more errors in the middle and fewer errors at the beginning and end of the series. Unfortunately, McCrary and Hunter did not present any statistical evaluation of the differences, nor did they discuss this apparent departure from the other two sets of observations. They concluded that any factor which decreases difficulty in serial verbal learning, "including meaning, familiarity, and quick learning ability" (*2*, p. 133), will produce gains at each position which are proportional to the total number of errors made. The McCrary-Hunter hypothesis states, in other words, that the form of the *relative* difficulty-position function is an invariant property of serial verbal learning.

To obtain more extensive individual-difference data bearing on this hypothesis, an experiment was conducted in which 120 subjects practiced a serial list of eight two-syllable nouns for ten trials. The subjects were undergraduate psychology students enrolled at Montana State University in 1958, all naive with respect to serial learning. The items were selected from the central portion of Noble's (*3*) scale of meaningfulness (m), such that the mean median m-value was 3.52. A Stoelting memory drum was used to expose the series, the interstimulus and intertrial periods being 2 and 4 seconds, respectively.

Following tabulation of the learning scores, the sample was stratified into five homogeneous levels of initial ability (A) of ten subjects each. The basis of the A classification was the total number of correct responses made during trials 1 to 4. These representative levels contained 37 men and 13 women, whose ages ranged from 17 to 34 (mean 20.1 yr). Cumulative scores earned by the five groups fell in these ranges: group I (slow), 0; group II (below average), 2; group III (average), 4; group IV (above average), 6 to 7; and group V (fast), 9 to 15. The mean numbers of correct responses in each group were 0.0, 2.0, 4.0, 6.5, and 11.7, respectively. Difficulty values for each ability group were then computed on the basis of mean total errors (absolute difficulty) and mean percentage of total errors (relative difficulty) at the eight serial positions during trials 1 to 10. In determining the latter measurements, percentage scores were calculated for each subject separately before averaging over the group ($n = 10$). This procedure amounts to equal weighting by subjects rather than by responses and hence is statistically more valid than the short-cut of using total group errors per position as the divisor.

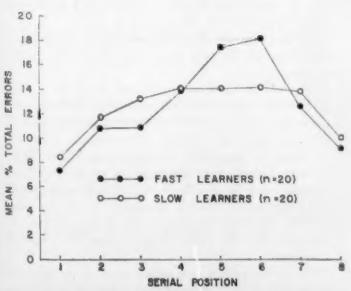

Fig. 1. Relative difficulty as a function of serial position, with learning ability as the parameter.

Table 1. Absolute versus relative difficulty (measured by mean total errors and mean percentage of total errors, respectively) of various serial positions as a function of initial ability level.

Ability group (A)	Serial position (P)							
	1	2	3	4	5	6	7	8
	Mean total errors							
I	6.5	8.3	8.9	9.2	9.2	9.5	9.1	7.1
II	4.6	7.2	8.3	9.2	9.1	8.9	8.9	6.1
III	3.0	5.1	7.0	7.6	9.1	7.9	7.9	5.9
IV	3.2	4.2	4.2	5.7	7.4	7.8	5.1	4.6
V	2.3	3.8	3.9	4.6	5.7	5.6	4.3	2.5
	Mean total errors (%)							
I	9.5	12.2	13.2	13.5	13.6	14.0	13.5	10.5
II	7.4	11.5	13.3	14.8	14.6	14.3	14.4	9.7
III	5.7	9.4	13.0	14.2	17.0	14.8	14.8	11.1
IV	7.5	10.5	9.9	13.4	17.4	18.6	12.1	10.7
V	7.1	10.8	11.7	14.1	17.4	17.9	13.2	7.8

Table 1 presents the general results of the experiment. From the *absolute* error measure in the upper half of the table, it is clear that difficulty is progressively reduced as initial ability level increases. When plotted, each frequency curve shows the classical bowed form, with the point of maximum difficulty just past the middle of the series. Turning now to the *relative* error measure in the lower half of the table, we find that the percentage curves tend to merge but are not identical. Instead, there is a disproportionate relationship between learning ability and the difficulty of the various serial positions. As a statistical test of the null (McCrary-Hunter) hypothesis that no real differences exist among the five groups when percentage measures are employed, an 8×5 type I mixed-factorial analysis of variance (*4*) was performed upon the relative error scores in Table 1. The main effect of serial position (P) is significant ($F = 30.87$; $df = 7/315$; $p < .001$); the main effect of initial ability (A) fails to reach the 5-percent level ($F = 2.25$; $df = 4/45$; $p > .05$); but the $P \times A$ interaction is significant ($F = 1.59$; $df = 28/315$; $p < .05$).

For our purposes, the most salient finding is the significant interaction variance, which means that the obtained differences in trend among the ability levels cannot reasonably be attributed to chance. Figure 1 illustrates graphically the systematic tendency of fast learners to make proportionately more errors in the middle and fewer errors at the beginning and end of the series. For clarity, groups I and II of Table 1 have been combined as "slow" learners while groups IV and V have been combined as "fast" learners. There is a striking resemblance to the comparable McCrary-Hunter graph (*2*, Fig. 5). Although our experiment confirms McCrary and Hunter's data, it thus paradoxically refutes the overgeneralized constancy interpretation offered by McCrary and Hunter.

We conclude that the form of the relative difficulty-position function is not an invariant property of rote memorization. At best, as in the case of certain laws of psychophysics, there is only a partial invariance in this domain. The probability distribution of errors in serial verbal learning is significantly affected by individual differences in ability to learn.

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25 September 1958

Efficient Method for Selection of Auxotrophic Mutants of Neurospora

Abstract. A technique for the selection of induced and spontaneous auxotrophic mutants of *Neurospora* in relatively high frequency is described. The method takes advantage of the reduced rate of death of germinating conidia of an inositol-requiring strain when a secondary mutation is imposed.

One of the shortcomings of *Neurospora crassa* for genetic and biochemical investigation has been the difficulty of obtaining large numbers of auxotrophic mutants of an induced or spontaneous origin. Most of the methods employed (*1*) have been cumbersome, tedious, and inefficient and have had only limited usefulness in the selection of spontaneous mutants.

Conidia of the inositol-requiring strain 37401 were observed to die rapidly when allowed to germinate in a medium devoid of inositol (*2, 3*). The loss of viability of the conidia is sharply reduced by inhibiting extensive germination with amino acid analogs in the incubation medium (*3*) or by imposing an amino acid requirement on the inositol-requiring strain by synthesizing double mutants through the appropriate crosses. The double mutant *inos-tryp-3* (37401-S1952), which requires tryptophan in addition to inositol for growth, has a conidial inactivation rate 70-fold less than that of the *inos* strain.

The inhibition of "inositol-less death" by the superimposition of an additional growth-factor requirement suggested that there would be a selective advantage for induced auxotrophic mutants in an *inos* genetic background under conditions of inositol deprivation. The enrichment for new auxotrophic mutants under selective circumstances would be, in principle, analogous to the successful mutant enrichment procedure employing a mutant of *Escherichia coli* blocked prior to the synthesis of the essential cell wall component diaminopimelic acid (*4*).

The inositol-requiring strain 89601a was used in the irradiation experiments described below in order to minimize the number of reversions to prototrophy (*5*). Conidia were harvested from 4-day liquid cultures grown at 30°C in a synthetic medium (*6*) with 2 percent sucrose and 5 μg of inositol per milliliter. The conidia were filtered through sterile cotton to remove mycelial bits and washed three times by alternate centrifugation and resuspension in sterile distilled water. The spores, adjusted to a concentration of 10^7 per milliliter, were irradiated (*7*) with ultraviolet light until a survival of 2 to 20 percent was obtained. To minimize the loss of induced mutations because of the possible involvement of a delay in phenotypic expression, the conidia, at a concentration of 10^6 per milliliter, were incubated in 1-percent sucrose synthetic medium with 0.25 μg of inositol per milliliter for 6 hr at 25°C. The suspension was vigorously shaken to prevent heterocaryosis. The suspension was then filtered through glass wool to remove germinated conidia and washed three times by alternate centrifugation and resuspension in sterile distilled water. After the suspension had been adjusted to a concentration of 10^7 to 10^8 conidia per milliliter, 1-ml aliquots were plated in 12 ml of synthetic minimal sorbose medium (*8*). The plates were incubated for 2 to 4 days at 34°C and supplemented with "4X" complete sorbose medium (*8*). After incubation for 3 days at 34°C, the colonies were counted and transferred to glycerol-complete slants and subsequently tested for their phenotype.

Table 1. Frequency of mutants obtained from irradiated and nonirradiated conidia of an inositol-requiring strain of *Neurospora* after subjection to "inositol-less death."

Survival frequency after irradiation	Viable conidia per plate (No.)	Incubation (day)	Frequency of survivors after incubation	Cultures tested (No.)	Mutants	
					(No.)	Frequency among cultures tested
			Experiment 1			
*	5.6×10^6	4	0.75×10^{-6}	39	6	0.15
0.21	1×10^6	4	2.70×10^{-5}	188	152	0.81
			Experiment 2			
*	7.8×10^6	4	0.90×10^{-6}	6	1	0.17
0.21	1.6×10^6	4	3.10×10^{-5}	30	27	0.90
			Experiment 3			
*	4.8×10^7	2	1.10×10^{-6}	200	3	0.015
0.027	1.3×10^6	2	7.70×10^{-6}	52	24	0.46
			Experiment 4			
*	1.2×10^7	4	9.10×10^{-7}	32	1	0.03
0.33	4×10^6	4	5.50×10^{-6}	71	51	0.72
0.20	2.6×10^6	4	1.90×10^{-6}	41	31	0.76

* Nonirradiated sample.

The results of a number of experiments are summarized in Table 1. In every case the frequency of mutants obtained was equal to or greater than that reported for any of the procedures previously employed. Since each colony represents a single macroconidium plated, each induced mutant obtained probably represents an individual mutational event. The results seem encouraging, particularly since many mutants are not recovered as a result of the effective multinucleate character of many of the macroconidia. It should be noted that there has evidently been an extensive enrichment of spontaneous mutants.

Although the method as described seems efficient, minor modifications may further improve the yield of mutants. The necessity of preincubation for phenotypic expression has not been unequivocally demonstrated, but when this step was omitted the yield was occasionally comparatively low. The time of incubation on minimal medium is apparently significant and might also be modified. The spectrum of mutant types recovered includes a high frequency of amino acid auxotrophs, some purine- and pyrimidine-requiring mutants, 3 to 4 percent morphological mutants, and an occasional vitamin-requiring mutant. A high frequency of leucine-requiring mutants has been observed in all experiments (*9*).

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7. A Westinghouse 3-w "germicidal" lamp at a distance of 30 cm was the ultraviolet light source.
8. The sorbose medium suggested to us by P. St. Lawrence contained 1.5 percent sorbose, 0.2 percent glycerol, 0.2 percent glucose, and 2 percent agar in Vogel's N synthetic minimal medium. The "4X" complete medium contained 5 mg of inositol, 10 g of Difco yeast extract, 4 g of Sheffield N Z Case, and 40 ml of a synthetic vitamin mixture [E. L. Tatum, R. W. Barratt, N. Fries, D. Bonner, *Am. J. Botany* 37, 38 (1950)] per liter of sorbose medium.
9. This investigation was aided in part by a grant from the U.S. Public Health Service (C-3610).

25 November 1958

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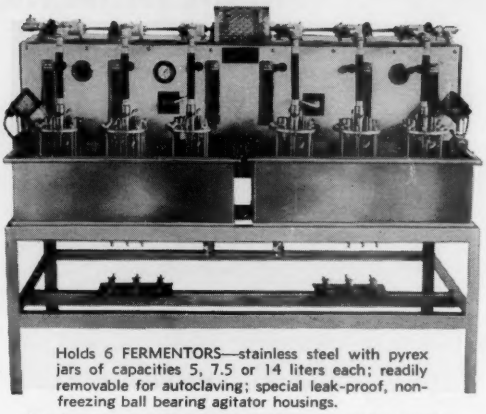

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PREGNANDIOL (pfs)	1 gram	10.00
Pregnan-3α, 20α Diol	250 mg	3.60
PREGNANDIOL-3α, 20α (allo) (pfs)	1 gram	10.00
PREGNANE-17α-21-DIOL-3,20-DIONE-21-ACETATE (pfs)	100 mg	4.00
PREGNANE-17α-21-DIOL-3,11,20-TRIONE-21-ACETATE (pfs)	100 mg	4.00
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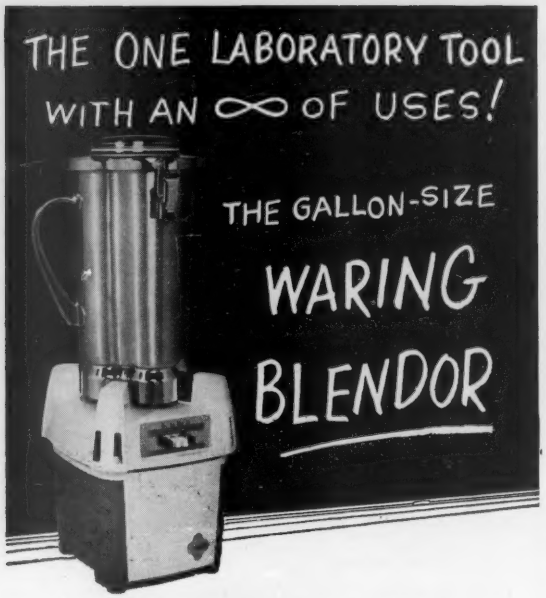

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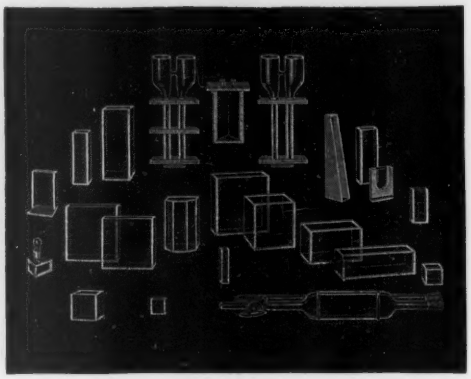

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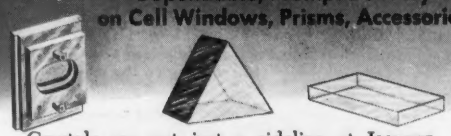

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Meetings

Social Sciences

The newly formed Associazione Italiana di Scienze Sociali, in conjunction with the Centro Nazionale di Prevenzione e Difesa Sociale, held the First National Congress of Social Sciences at the Palazzo Serbelloni-Cabiati in Milan, 31 May to 2 June 1958.

The association was formed about a year ago in response to a felt need for an organization that would facilitate contact among all those who, in various scientific disciplines, concern themselves with the study of society, with special regard to contemporary Italian society and culture.

The congress was divided into two distinct parts. The first (theoretical), on the integration of the social sciences, considered the premises of the various social sciences and the problem of their interdependence; the second (applied), on city and farm areas, dealt with the specific problem of the relation between urban and rural populations, and with research already completed.

The actual proceedings consisted of a presentation of short summaries of papers that had been printed and gathered in a large volume in time for distribution at the congress. Following these summaries, the discussion was opened and took the greater part of the time. This made it possible both to study a paper carefully and to have sufficient time to make a substantial contribution to the discussion.

Speakers and discussants in the first part of the program addressed themselves to the problem of definition and interdependence of the various social sciences and the connection between these and philosophy. Much interest was shown in breaking out of the traditional academic boundaries, and a genuine effort was made to search for a fruitful approach. The debate raged, as was to be expected, around whether "complementarity" or "integration" (fusion) of the disciplines would yield best results. Also discussed at length were the relations of the social sciences to ethics and to philosophy. One of the speakers pointed out that "it seems no longer true that philosophy *tells* the social sciences what *should* be done."

The proceedings of the congress, and papers that were late, will shortly be published in a second volume.

The congress was attended by a large number of people, from Italy and other countries, prominent in such fields as sociology, social anthropology, social psychology, economics, jurisprudence, social medicine, and philosophy.

The president of the association is Renato Treves of the University of Milan. Tullio Tentori, professor at the University of Rome and director of the Museo delle Arti e Tradizioni Popolari of Rome, is national secretary.

RENATO TAGIURI
Graduate School of Business Administration, Harvard University, Boston, Massachusetts

Forthcoming Events

March

24. Admissions Policies to Serve the Needs of the Community, symp., Cleveland, Ohio. (B. G. Fricke, Univ. of Michigan, 120 Rackham Bldg., Ann Arbor.)

27–28. **Michigan Acad. of Sciences,** East Lansing. (D. A. Rings, Univ. of Michigan, Dept. of Engineering, Ann Arbor.)

27–28. Pennsylvania Acad. of Sciences, Gettysburg. (K. Dearolf, Public Museum and Art Gallery, Reading, Pa.)

28. South Carolina Acad. of Sciences, Columbia. (H. W. Freeman, Dept. of Biology, Winthrop College, Rock Hill, S.C.)

29–3. Association for Childhood Education International, 1959 study conf., St. Louis, Mo. (ACEI, 1200 15 St., NW, Washington 5.)

29–3. Latin American Congress of Chemistry, 7th, Mexico D.F., Mexico. (R. I. Frisbie, Calle Ciprès No. 176, Zone 4. Mexico, D.F.)

30–31. Third Teratology Conf., Portland, Ore. (D. L. Gunberg, Dept. of Anatomy, Univ. of Oregon Medical School, Portland.)

30–1. American Orthopsychiatric Assoc., San Francisco, Calif. (M. F. Langer, 1790 Broadway, New York 19.)

30–12. Bahamas Medical Conf., 7th, Nassau. (B. L. Frank, 1290 Pine Ave., W. Montreal, Canada.)

31–2. American Power Conf., 21st annual, Chicago, Ill. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

31–2. Symposium on Millimeter Waves. 9th, New York, N.Y. (H. J. Carlin, Microwave Research Inst., 55 Johnson St., Brooklyn 1, N.Y.)

31–4. National Science Teachers Assoc., 7th natl. conv., Atlantic City, N.J. (R. H. Carlton, NSTA, 1201 16 St., NW, Washington 6.)

31–5. International Committee of Military Medicine and Pharmacy, 21st session Paris, France. (Comité International de Médecine et de Pharmacie Militaires, Hôpital Militaire, 79, rue Saint Laurent, Liège, Belgium.)

April

1–3. American Assoc. of Anatomists, Seattle, Wash. (B. Flexner, Univ. of Pennsylvania Medical School, Philadelphia 4.)

1–4. National Council of Teachers of Mathematics, Dallas, Tex. (H. T. Karnes, Dept. of Mathematics, Louisiana State Univ., Baton Rouge 3.)

1–4. National Speleological Soc., 16th annual conv., Springfield, Mo. (O. Hawksley, Route 5, Warrensburg, Mo.)

1–4. Neurosurgical Soc. of America, Hot Springs, Va. (F. P. Smith, 260 Crittenden Blvd., Rochester, 20, N.Y.)

1–29. World Meteorological Organization, 3rd session of congress, Geneva, Switzerland. (WMO, Campagne Rigot, 1, avenue de la Paix, Geneva.)

2–3. Electrically Exploded Wires, conf., Boston, Mass. (W. G. Chace, Thermal Radiation Laboratory, CRZCM, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Mass.)

2–3. Southern Municipal and Industrial Waste Conference, 8th, Chapel Hill, N.C. (University Extension Division, Short Courses, P.O. Box 1050, Chapel Hill, N.C.)

2–4. Association of American Geographers, 55th annual, Pittsburgh, Pa. (J. E. Guernsey, 9707 Parkwood Dr., Bethesda, Md.)

2–4. Association for Computing Machinery, Cleveland, Ohio. (J. Moshman, Corporation for Economic and Industrial Research, 1200 Jefferson Davis Highway, Arlington 2, Va.)

2–4. Optical Soc. of America, New York, N.Y. (S. S. Ballard, Dept. of Physics, Univ. of Florida, Gainesville.)

3–4. Eastern Psychological Assoc., Atlantic City, N.J. (C. H. Rush, Standard Oil Co. of New Jersey, Rockefeller Plaza, New York, N.Y.)

3–5. American Soc. for the Study of Sterility, Atlantic City, N.J. (H. H. Thomas, 920 S. 19 St., Birmingham 5, Ala.)

3–5. Cooper Ornithological Soc., Berkeley, Calif. (J. Davis, Univ. of California, Hastings Reservation, Jamesburg Route, Carmel Valley.)

5–7. Vaccination against Tuberculosis with Non-Living Vaccines, intern. symp., Florence, Italy. (D. W. Weiss, Dept. of Bacteriology, Univ. of California, Berkeley 4.)

5–9. American College of Obstetricians and Gynecologists, Atlantic City, N.J. (J. C. Ullery, 15 S. Clark St., Chicago 3, Ill.)

5–9. International Acad. of Proctology, 11th annual New York, N.Y. (A. J. Cantor, IAP, 147–41 Sanford Ave., Flushing 55, N.Y.)

5–10. American Chemical Soc., 135th, Boston, Mass. (M. A. H. Emery, 18th and K St., NW, Washington, D.C.)

5–10. Nuclear Congress, Cleveland, Ohio. (S. Baron, Burns & Roe, Inc., 160 West Broadway, New York 13.)

6. Paleontological Research Institution, Ithaca, N.Y. (R. Harris, 109 Dearborn Rd., Ithaca.)

6–7. Chemical and Petroleum Instrumentation, 2nd natl. symp., St Louis, Mo. (H. S. Kindler, Director of Technical and Educational Services, ISA, 313 Sixth Ave., Pittsburgh 22, Pa.)

6–8. American Radium Soc., Hot Springs, Va. (R. L. Brown, Robert Winship Clinic, Emory Univ., Atlanta 22, Ga.)

6–8. National Open Hearth Steel Furnace, Coke Oven and Raw Materials Conf., St. Louis, Mo. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

6–9. American Acad. of General Practice, San Francisco, Calif. (M. F. Cahal, Volker Blvd. at Brookside, Kansas City 12, Mo.)

6–11. Coordination Chemistry, intern. conf., London, England. (Chemical Soc., Burlington House, London, W.1.)

8. Evolution of Cell Populations, conf. (by invitation), Atlantic City, N.J. (D. C. Hetherington, Dept. of Anatomy, Duke Univ. School of Medicine, Durham, N.C.)

8–9. Tissue Culture Assoc., 10th annual, Atlantic City, N.J. (D. C. Hetherington, Dept. of Anatomy, Duke Univ. School of Medicine, Durham, N.C.)

10–11. Society for the Scientific Study of Religion, Chicago, Ill. (W. H. Clark, SSSR, Hartford Seminary Foundation, Hartford 5, Conn.)

10–16. Mental Health, 2nd Caribbean conf., St. Thomas, Virgin Islands. (Mrs. E. L. M. Shulterbrandt, Bureau of Mental Health, St. Thomas, V.I.)

12–13. American Soc. for Artificial Internal Organs, Atlantic City, N.J. (C. K. Kirby, ASAIO, 110 Maloney Bldg., University Hospital, 3600 Spruce St., Philadelphia 4, Pa.)

12–14. Atomic Mechanisms of Fracture, conf., Cambridge, Mass. (D. K. Felbeck, Natl. Acad. of Sciences–Natl. Research Council, 2101 Constitution Ave., NW, Washington 25.)

12–15. Neurosurgery, 8th Latin American cong., Santiago, Chile. (A. Asenjo G., Casilla 70-D, Santiago, Chile.)

(See issue of 20 February for comprehensive list)

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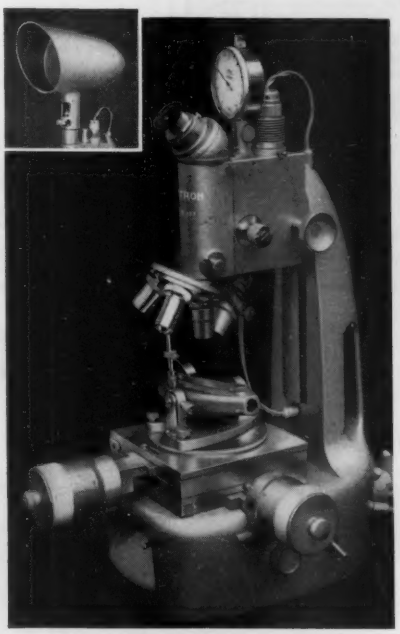

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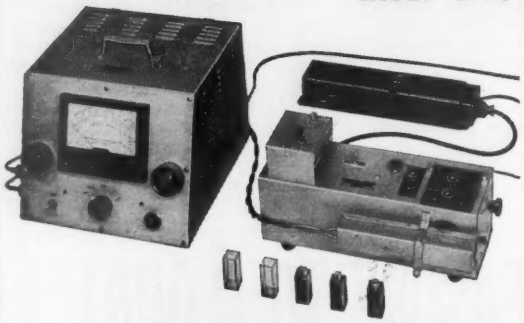

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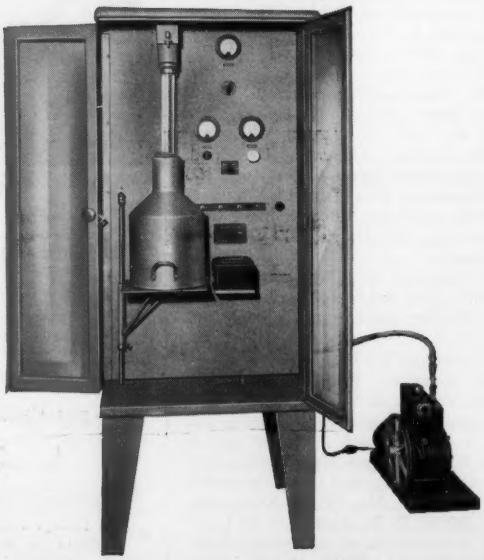

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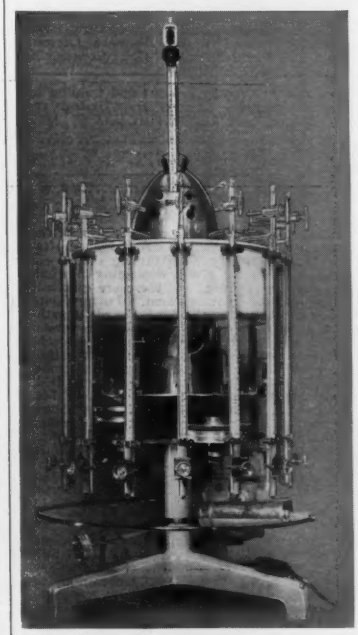

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Biologists. Ph.D's new state college, southern California. Prefer background in physiology, genetics, embryology, microbiology, or botany. Please send full résumé to Ralph Prator, President, San Fernando Valley State College, Northridge, California. 2/27

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Technical Employment Coordinator
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(a) Physician interested in research, well trained in biochemistry, with pediatric background; duties include director research program in psychiatry, cardiovascular diseases, leukemia, hematology, virus diseases, allergy; new research building, East. **(b) Ph.D.'s in Biochemistry and Pharmacology**; experience in proteins helpful but not essential; latter should be experienced in physiology and pharmacology; both candidates should possess administrative experience; $14,000; near university center, East. **(c) Clinical Microbiologist, Physician or Ph.D.**; duties include supervision of clinical bacteriology and research; one of leading clinics and teaching hospitals; Midwest. S2-4 Medical Bureau. Burneice Larson, Director, 900 North Michigan Avenue, Chicago. X

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27 February 1959

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☐ 536, B	☐ 573, UI	☐ 573, LI	☐ 573, O*	☐ 574, O
☐ 574, UI*	☐ 574, LI	☐ 575, I	☐ 575, O	☐ 576, UO
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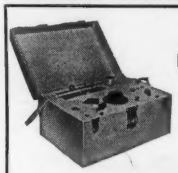

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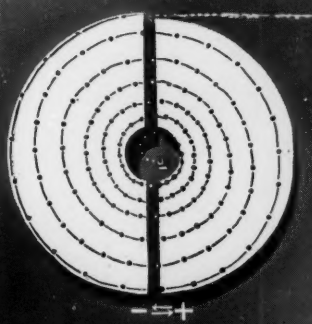
5 areas where the physicist may act to advance



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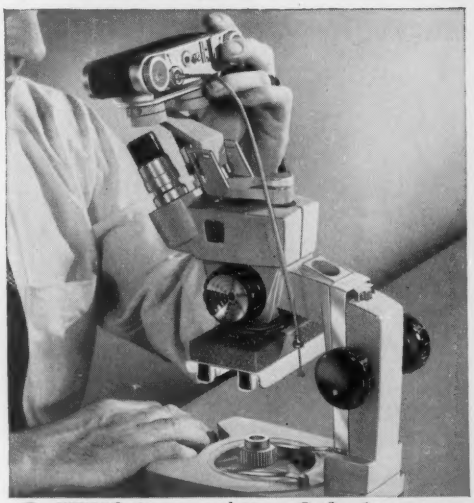

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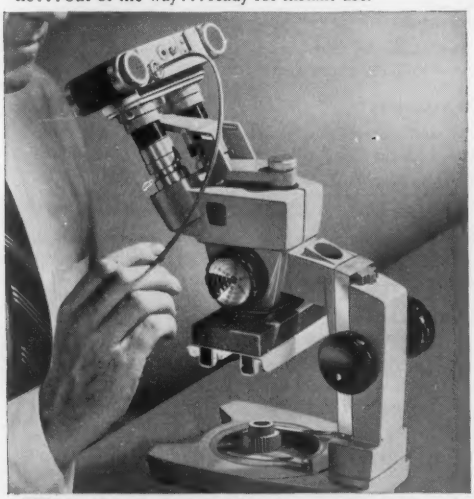

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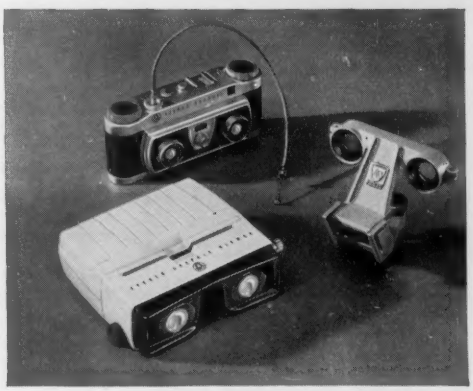

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